On the Determinants of Human Spatial Organization

By

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A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Doctor of Philosophy

in

Psychology

Waterloo, Ontario, Canada, 2020

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Study 1 is currently under review at *Applied Cognitive Psychology* (Zhu & Risko, under review). Studies 2 to 4 are currently under review at *The Quarterly Journal of Experimental Psychology* (Zhu & Risko, under review).

Abstract

Humans routinely organize and reorganize their environments, such as keeping one's bookshelves tidy or placing important documents in obvious locations to avoid forgetting about them. Spatial organization is widely thought to reduce both the physical and cognitive demands of a task in order to allow an individual to perform the task more easily. Yet, individuals do not always choose to engage in organizational behaviours when carrying out everyday tasks despite the utility of spatial organization. Across 10 studies, I examined the notion that human spatial organization is influenced by multiple, potentially competing, factors and provided evidence that individuals chose to engage in spatial organization not only when doing so resulted in a perceived benefit in task performance, but also when it aligned with their past habits and/or dispositions. The investigations presented in this dissertation highlight that the decision to engage in spatial organization is influenced by multiple factors that simultaneously compete for expression and offer a more nuanced and systematic understanding of human spatial organization.

Acknowledgement

I would like to thank my advisor, Evan, for taking me under his wing; for his mentorship and teachings, big and small; for allowing me free reign over my passions in academia and beyond while gently herding lest I stray too far; for inspiring and for believing. I could not have asked for a better advisor, who cares if not with words then with action.

To my lab mates, past and present, I could not have asked for better colleagues and even better friends. You were tirelessly encouraging when I faltered and trusted in me when I did not trust in myself. It has been a pleasure growing alongside and learning from each one of you.

I am and will forever be grateful for my mother, whose love and support I cannot even begin to measure with words. Thank you for being a soft cushion for my sometimes-awkward landings and for carving out the space and time that I needed to take flight once more.

Dedication

to you, for when you might need it most:

foul or pure, the boat will journey forth

be curious, stay true

and stray not for the easy course.

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Chapter 1

Background

As agents embedded in an ever-changing environment, we are constantly making decisions about where to place our objects or ourselves in relation to the environment, whether it involves choosing a parking spot at the mall or deciding how to arrange one's books and supplies in a workspace. While the kinds of everyday spatial decisions we make may seem mundane and inconsequential, the product of these decisions can play an important role in how we process and search for information (Solman & Kingstone, 2017a, 2017b), as well as how we interact with (Holahan, 1972; Koneya, 1976) and form impressions of others (Gosling, 2008; Gosling, Ko, Mannarelli, & Morris, 2002). Yet, research investigating how humans choose to organize their environments is relatively sparse despite spatial organization being a relatively ubiquitous phenomenon that occurs in a wide array of everyday situations. Earlier research in the field was spearheaded by cognitive scientist David Kirsh (1995, 1996), who proposed the intuitive idea that how an individual decides to organize (or reorganize) their environments is primarily based on performance considerations. By observing how experts arrange objects in their workspace, Kirsh (1995) argued that spatial organization can help to highlight or obscure certain choices in the environment, thereby reducing the amount of time or effort individuals spend on planning given actions. As such, arranging one's space in some cases can also allow individuals to reduce energetic costs associated with task performance by, for example, placing more relevant objects in more convenient locations (e.g., placing a coffee mug within immediate reach).

Following this general perspective, a number of studies have attempted to systematically investigate the relation between spatial configurations and task performance. Indeed, there is evidence to suggest that when individuals are provided with opportunities to spontaneously arrange their environments, they often reconfigure their environments to make frequently encountered objects more accessible (Solman & Kingstone, 2017a), especially when doing so helps to reduce the amount of physical effort required to access these frequently used objects (Zhu & Risko, 2016). For instance, Solman and Kingstone (2017b) examined the relation between how individuals arranged objects in a virtual environment and their performance in a dynamic search task. Participants were asked to search for target objects sequentially in an interactive task space where objects could be moved and rearranged at any point during the task. Importantly, the same objects could be encountered more than once in the search sequence and with varying frequency, wherein some objects were more frequently encountered compared to others. Further, the consistency with which object pairs (i.e., objects next to one another in a sequence) also varied: in one condition, there was a high probability that a given pair of objects would or would not appear next to one another in a search sequence (e.g., object A and object B would frequently appear next to each other, but they would never appear next to object C); and in the other condition, although some items did appear next to each other with a higher probability, the vast majority of object pairs appeared only once in the search sequence. Solman and Kingstone (2017b) found that individuals were, indeed, sensitive to how frequently they interacted with given objects in the search task and, in turn, modified their environments in response to this information. These organizational behaviours can be succinctly described as a tendency to move frequently encountered objects closer to the center of the task space, while moving infrequently used objects towards the periphery.

In addition to minimizing energetic costs, spatial organization is also thought to help with reducing task-related cognitive demands. A commonly reported issue in disorganized spaces is that individuals have a harder time accessing relevant information or items (Malone, 1983;

Williamson, 1998). Spatial organization can mitigate this issue when target items are placed in strategic locations within a space which can, for example, draw attention to these items (e.g., by placing important documents in an obvious location to serve as a reminder; Gilbert, 2015; Malone, 1983), facilitate more systematic search (e.g., placing cookware and utensils in the kitchen; Solman & Kingstone, 2017a), or allow for easier retrieval at a later time point (e.g., putting a set of keys in a designated location; Kirsh, 1995, 1996; Risko & Gilbert, 2016).

Although empirical work has demonstrated the utility afforded by spatial organization in a number of situations, individuals do not always opt to organize their environments, even when doing so could result in objective energetic or cognitive savings. In a study conducted by Zhu and Risko (2016), participants completed a symbol copying task using two different pairs of writing instruments. Participants began each block by placing a single writing utensil in two designated locations on a desk—one close and one further away from the individual—in any order they preferred. To complete each trial within the block, participants were given a visual cue that indicated which one of the writing instruments should be used, copied the symbol, and completed the trial by putting the writing utensil back. After each block, participants switched to a different set of writing instruments, and could again spontaneously arrange them in any order in the designated locations. Critically, participants were required to use some writing instruments in the sets far more frequently than others. In examining how individuals spontaneously placed the writing instruments at the start of each block, Zhu and Risko (2016) found that rather than moving more frequently used utensils closer to them, participants often maintained the initial location of each writing utensil in space throughout the task, even when doing so required a further reach and resulted in slower task performance overall. In fact, participants only chose to configure their space more efficiently (i.e., moving frequently used writing instruments closer) when the physical cost associated with the reach increased substantially. This suggests that individuals may base their decisions about where to place objects in future scenarios on spatial decisions made in the past, rather than considering the objective energetic costs associated with these placements if these costs are not sufficiently high.

This discrepancy between the potential benefits of spatial organization and the lack of engagement in organizational activity was further demonstrated in a series of studies involving school-aged children (Berry, Allen, Mon-Williams, & Waterman, 2019). Children were asked to perform a spatial working memory task that involved searching for a sequence of colour blocks among an array of blocks after the sequence was presented verbally. Notably, all children completed two conditions of the same task, one in which the array could be grouped such that blocks of the same colour category would be placed together in space and the other wherein blocks were pseudorandomly arranged such that adjacent blocks were always of different colours. Berry and colleagues (2019) found that children with a lower working memory capacity (WMC) performed better on the working memory task when the blocks were organized by colour than when the blocks were pseudorandomly placed. On the other hand, though children with a higher WMC performed better overall compared to children with a lower WMC, their performance did not differ across the two conditions. This suggests that children with a lower WMC benefited more from systematically organized task environments than those with a higher working memory capacity. However, when asked to rate the difficulty of the two conditions using Likert scales, the majority of children with higher WMC (85%) identified that the ordered condition was easier, whereas only 57% of the children with a lower WMC did so. That is, although children with a lower WMC benefitted more from an organized environment, they had more difficulty recognizing that spatial organization facilitated their task performance. Equally counterintuitive was that children—regardless of their working memory capacity—opted for a more random spatial arrangement than an organized one, when presented with the opportunity to freely arrange their environment. In other words, although children with a higher WMC rated the organized condition as being easier, they did not choose to reorganize their task space in this manner. These results suggest that individuals often forego spatial organization despite being aware that doing so would be beneficial.

Though it may seem puzzling that individuals do not always choose to organize their task environments even though an organized environment would help facilitate task performance, it is important to note that, while a well-structured space can help individuals to conserve time and effort when completing tasks, the construction and maintenance of that organized environment itself requires time and effort. As such, individuals' decision to engage in organization may reflect how individuals weigh the effort it takes to construct or maintain an ordered environment against the benefits of operating, navigating, or searching within the resulting environment. In addition, as individuals interact with their environment over time, how they choose to arrange their spaces may be influenced by a variety of factors aside from performance considerations, such as the spatial habits they form within that space (Zhu & Risko, 2016). Based on this perspective, human spatial organization may be influenced by a variety of factors such that individuals would choose to organize or reconfigure their environments when doing so is expected to result in a *perceived* net benefit.

Present Investigation

An overarching theme in the current thesis is to provide a more nuanced look at various factors that may influence the way individuals interact with their environments. In Chapter 1, I provided real-world evidence that individuals may consider factors other than task performance when deciding where to position themselves within a given space. In the remaining chapters, I took a deeper dive to examine how individuals decided when to engage in spatial organization behaviour. In Chapters 2 and 3, I investigated the extent to which individuals considered task time, effort, and enjoyability when deciding whether to use spatial organization in the context of a search task. Across these two chapters, I found that individuals consistently considered task time when determining whether or not an organization-based strategy would be selected. To supplement these correlational results, task time was manipulated in Chapter 4 to establish a causal link between task time and the type of search strategy individuals selected. In addition to task time, I also examined the role that individual differences may play in how likely individuals were to choose an organization-based search strategy across Chapters 4 and 5.

Chapter 2

Zhu and Risko (2016) provided preliminary evidence that spatial decisions may be more complex than previously emphasized (e.g., Kirsh, 1995), and that there are likely multiple—and sometimes competing—factors at play. Specifically, in addition to performance considerations, individuals also seemed to consider where an object was previously placed in the environment. In the current chapter, I aimed to extend this notion of spatial habit and examined how spatial decisions—decisions about where to place our bodies or objects when multiple alternatives were present—would unfold over time. To do so, I tracked where students chose to sit in a classroom over a 12-week period. Studying seating arrangement in classrooms offers several advantages over setups presented in previous experiments (e.g., Zhu & Risko, 2016). Firstly, individuals have multiple opportunities to make spatial decisions in the same environment and can do so over an extended timespan. This allowed us to gain a more in-depth understanding of the trajectory of spatial decisions and spatial habit formation as a function of time. Further, classrooms provide a relatively large range of available locations for individuals to select from and the act of selecting seats in a classroom is not associated with any direct performance benefits, unlike in previous experimental designs (e.g., Zhu & Risko, 2016). In other words, the current study allowed us to examine the role of spatial habit on spatial decisions in a less restricted environment, with minimal influence from possible performance trade-offs (e.g., response time or task accuracy) as a direct result of the seat selection itself. Finally, although laboratory-based experiments provide a medium through which factors can be isolated and controlled, behaviours observed in laboratory settings can sometimes deviate from how they organically emerge in real-world settings (Kingstone, Smilek, & Eastwood, 2008; Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012). Thus, the naturalistic observation approach adopted here is a useful complement to, and check on, more controlled work.

In the context of seating choices, evidence that individuals formed spatial habits over time would take the form of individuals becoming more likely to sit in a given location over time. To measure this, I chose to examine the distance between seats chosen across adjacent days of each class. For instance, a score of 0 would mean that the individual stayed in the same seat across two adjacent classes. Evidence for the formation of a spatial habit would be found if seating distance between adjacent classes decreased over time. On the other hand, individuals may come into this task environment with an already-strong spatial preference (e.g., preferring to sit near the front of the class rather than near the middle or the back) that they carry with them from previous experiences. If a strong preference has already present, then seating choice should not become increasingly constrained over time; rather it should remain relatively consistent throughout the course (i.e., a lack of relation between seating choice and time).

Study 1

Method

Archived information regarding students' login activity was obtained from a university database. In order to maximize power in this study, I obtained data for all available classes that were comparable in size and format (i.e., small lecture-based classes). This resulted in data collected from 4 courses that took place in a common computer lab with 42 available seating spaces. This data set provided information regarding which computers users logged on to and timestamps for each instance that a student logged on to or out of a computer. For each computer station, I obtained x- and y-coordinates for each seat by measuring the distance between the center of each computer station and an arbitrary reference point (see Figure 1 for a layout of the classroom). The classes comprised two sessions each of two different courses. For one course, classes occurred once a week and had two unit exams (one mid-way through the course and one on the last day of classes). For the other course, classes occurred twice a week and there were 5 unit exams throughout the course (roughly one exam every other week, with the last unit exam falling on the final day of class). Note that a number of students also opted to bring their own laptops; as such, I did not obtain login information for these students. Data were collected from 66 students across all 4 classes; 27 of these students had taken both classes. This resulted in a total of 1718 seating choice observations.

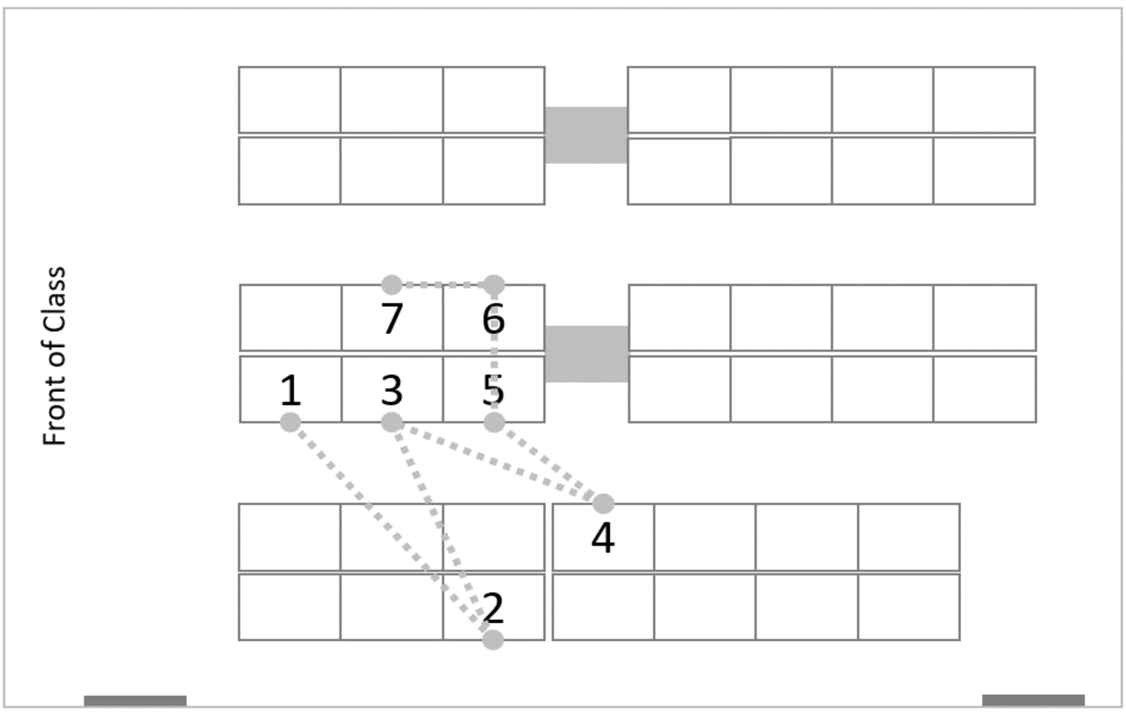


Figure 1. A visual depiction of the layout of the classroom and an example the distance between seats on two adjacent days (e.g., day 1 and day 2, day 2 and day 3, etc.). The dark grey bars at the bottom of the figure represent the location of the entrances. Aside from the computer stations, there are also two pillars (represented as grey boxes in the figure) in the room. The

center of the seat facing the computer screen (as shown by the solid dots) are measured with regards to the origin (i.e., bottom left corner of the room). The numbers indicate the order in which seats were selected.

Exclusion Criteria

The data set reflected individuals' naturalistic behaviours in classrooms such that users were free to switch between different seats or log in and out of computer stations at any point during class (e.g., logging out during break time in class). As such, I applied a number of exclusion criteria to ensure that seating choice could be meaningfully analyzed and interpreted. Firstly, I included only login sessions from 30 minutes before the start of the lecture through to the end of class. Secondly, if a student made multiple login attempts in the same class, I included only the entry for the first login session as long as the login session was at least 5 minutes in duration. After these exclusion criteria were applied, 1412 observations remained.

Because the classroom is a dynamic environment, one factor that may influence a user's seating choice is their time of arrival relative to others in the class. To account for this, I ordered individuals based on the timestamp of their first valid login session. If two or more users had the same login timestamp, the same order number was assigned to them and the next individual would be assigned an order number equal to the total number of people with an earlier timestamp than them (i.e., the first two people who arrived at the same time would both be assigned an order number of 1; the next person after them would be assigned an order number of 3).

Analysis

In order to more easily interpret two-dimensional spatial coordinates with respect to the research hypothesis, I calculated the Euclidean distances between the coordinates for a seat on any given day to the coordinates of the seat chosen the day immediately before. If coordinates for a given date were missing, then a difference score could not be calculated for that day or the day after, and these data points were not included in the analysis. This resulted in the exclusion of 112 observations in the data set; as a result, one individual was removed due to insufficient data (i.e., they contributed fewer than two data points).

Since the same individuals made multiple spatial decisions over the course of a semester (and sometimes across different courses), mixed-effects models were used to account for the within-subject variance in seating choice. This was conducted using the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015) in R (R Core Team, 2019), and maximum likelihood estimation was used in fitting the model. Time, as measured by the number of days since the first day of class in each course, as well as individuals' order of arrival on each day, were both centered and included as fixed factors in the model. Individual students (rather than sets of observations) were included as a random effect, and only the intercept was allowed to vary by individual. Given that degrees of freedom can be difficult to estimate accurately in mixed-effects models (Bates et al., 2015), I provide approximated *p*-values using Wald *z*-statistics via the *sjPlot* package (Lüdecke, 2018) considering the relatively large number of observations in the current study. The formatting of summary tables was also done using the *sjPlot* package. Note that marginal and conditional R^2 were reported for mixed-effects models wherein marginal R^2 details the amount of variance explained by the fixed effects only, whereas conditional R^2 reflects the variance explained by the fixed and random effects combined (Nakagawa & Schielzeth, 2013).

Results

Linear Effect of Time on Seating Choice

As shown in Table 1, results of this linear mixed-effects model showed that order of arrival was a significant predictor of seating distance such that individuals tended to sit farther away from their seat in the previous class if they arrived later relative to their peers, b = .057, 95% CI [.039, .075], t = 6.36, p < .001. Critically, the distance between seats chosen on adjacent days reduced linearly as a function of time, b = -.011, 95% CI [-.015, -.007], t = 5.58, p < .001 (see Figure 2A).

Table 1.

Linear mixed-effects model using seating distance between seating choice in adjacent class sessions as the criterion variable.

	Seating Distance			
Predictors	*b*	*CI*	*Wald z-statistic*	*p*
Intercept	1.840	1.607 – 2.072	15.521	**<0.001**
Time	-0.011	-0.015 – -0.007	-5.577	**<0.001**
Order of Arrival	0.057	0.039 – 0.075	6.356	**<0.001**
Random Effects				
σ^2	3.08			
$\tau_{00\ ID}$	0.71			
ICC	0.19			
N_{ID}	65			
Observations	1300			
Marginal R^2 / Conditional R^2	0.051 / 0.230			
AIC	5268.160			

Note. Unstandardized b-weights listed.

In addition to general seating distance, I also looked at the number of individuals who chose to sit in the same seat on adjacent days (i.e., with a difference score of 0) and whether it changed as a function of time. For this, anyone who sat in the same seat on adjacent days were assigned a score of 1, and those who did not were assigned a score of 0. Similar to the previous analysis, a logistic mixed-effects model revealed that later arrival resulted in a significant decrease in the likelihood of sitting in the same seat, $b = -.07$, 95% CI [-.094, -.046], $z = 5.75$, $p < .001$, while the likelihood of sitting in the same seat increased with time, $b = .008$, 95% CI [.003, .013], $z = 3.05$, $p = .002$ (see Table 2 and Figure 2B). Interestingly, a linear mixed-effects model looking at students who did not choose to stay in the same spot on adjacent days revealed a negative linear trend between seating distance and time, $b = -.011$, 95% CI [-.015, -.006], $t = 4.65$, $p < .001$ (see Table 3). This suggests that individuals were not only more likely to sit in the same seats as a course progressed, there was also an overall reduction in their seating distance across time. Altogether, the analyses thus far support the notion that seating distance becomes more constrained over time.

Table 2.

Logistic mixed-effects model using whether individuals sat in the same seat in adjacent class sessions as the criterion variable. Same seating position in adjacent class session was coded as 1 and different seating positions were coded as 0.

	Proportion Choosing Same Seat			
Predictors	*Log-Odds*	*CI*	*Wald z-Statistic*	*p*
Intercept	-0.587	-0.905 – -0.270	-3.626	**<0.001**
Time	0.008	0.003 – 0.013	3.051	**0.002**
Order of Arrival	-0.070	-0.094 – -0.046	-5.753	**<0.001**
Random Effects				
σ^2	3.29			
$\tau_{00\ ID}$	1.31			
ICC	0.28			
N_{ID}	65			
Observations	1300			
Marginal R^2 / Conditional R^2	0.048 / 0.319			
AIC	1515.716			

Table 3.

Linear mixed-effects model using seating distance (excluding any data wherein individuals sat in the same location, i.e., having a seating distance of 0) between seating choice in adjacent class sessions as the criterion variable.

	Seating Distance			
Predictors	*b*	*CI*	*Wald z-Statistic*	*p*
Intercept	2.960	2.747 – 3.174	27.179	**<0.001**
Time	-0.011	-0.015 – -0.006	-4.654	**<0.001**
Order of Arrival	0.030	0.010 – 0.050	2.892	**0.004**
Random Effects				
σ^2	2.64			
$\tau_{00\ ID}$	0.47			
ICC	0.15			
N_{ID}	61			
Observations	800			
Marginal R^2 / Conditional R^2	0.033 / 0.178			
AIC	3126.064			

Note. Unstandardized b-weights listed.

Curvilinear Effect of Time on Seating Choice

A closer examination of the mean distance between seating choices for each week (i.e., solid triangles in Figure 2) revealed that while seating choice does become more fixed over time, there was an unexpected increase in seating distance near the end of courses. To examine the observed curvilinear relation, I added time as a quadratic variable to the existing linear mixed-effects model. The results are summarized in Table 4. As with the previous model, order of arrival remained a significant predictor, *b* = .056, 95% CI [.038, .074], *t* = 6.25, *p* < .001, and the curvilinear relation was indeed also significant, *b* = .0002, 95% CI [.00005, .00042], *t* = 2.54, *p* = .011. Importantly, adding time as a quadratic factor significantly improved the goodness of fit compared to a model with only first-order polynomial variables, $\chi^2(1) = 6.44$, *p* = .011. This curvilinear relation went away when I excluded the data points associated with the last day of class, *b* = .00002, 95% CI [-.00019, .00022], *t* = .16, *p* = .87.

Table 4.

Linear mixed-effects model using seating distance between seating choice in adjacent class sessions as the criterion variable.

	Seating Distance			
Predictors	*Estimates*	*CI*	*Statistic*	*p*
Intercept	1.691	1.432 – 1.951	12.776	**<0.001**
Time	-0.011	-0.015 – -0.007	-5.621	**<0.001**
Order of Arrival	0.056	0.038 – 0.074	6.246	**<0.001**
Time^2	0.0002	0.0001 – 0.0004	2.541	**0.011**
Random Effects				
σ^2	3.06			
$\tau_{00\ ID}$	0.72			
ICC	0.19			
N_{ID}	65			
Observations	1300			
Marginal R^2 / Conditional R^2	0.055 / 0.235			
AIC	5263.722			

Note. Unstandardized b-weights listed.

One potential reason for the increase in seating distance at the end of the courses might be that in all courses examined in this study, the final unit exam fell on the last day of classes. As such, I wanted to investigate whether there was a difference in seating behaviour between lecture sessions and all unit exams, or if the increase in seating distance was specific only to the last unit exam (and correspondingly the last day of class). During exam sessions, students may have different goals than during lecture sessions (e.g., to avoid faulty or slow computers as opposed to sitting with friends), which may be reflected in their seating choices. These patterns may be obscured in the way the current data is presented, as not all unit exams fell on the same days across different courses (except for the last unit exams). If this account is true, then I would expect there to be an increase in seating distance for not only the last unit exam relative to previous lecture sessions, but other exam sessions as well.

To test this idea, I conducted a linear mixed-effects model to examine whether the distance from a previously chosen seat on lecture versus exam days would be moderated by the type of exam (i.e., last unit exam vs. other unit exams). If the above account is true, then I would not expect the interaction term to be a significant predictor. For this analysis, I only included sets of observations that contained data across all 4 cells to ensure that if the results aligned with the research prediction, it would be the same individuals contributing to the observed effect. This resulted in a subset of 62 sets of observations comprising 49 individuals. As with previous mixed-effects models, individuals (rather than sets of observations) was included as a random factor wherein only the intercept was allowed to vary by individual. Contrary to the idea that seating behaviour differed on exam versus lecture sessions in general, the analysis revealed a significant interaction between class type (lecture vs. exam) across different exam types (final exam vs. other exams), $b = -.27$, 95% CI [-.45, -.08], $t = 2.78$, $p = .005$. Specifically, follow-up analyses showed that the seating distance from a previous class was significantly larger on exam days (*M* = 2.40) compared to the immediately preceding lecture sessions (*M* = 1.23; *b* = 1.17, 95% CI [.65, 1.69], *t* = 4.40, *p* < .001). However, the observed increase in seating distance was localized to the last exam session, as no difference in seating distance was found for the remaining unit exams on the day of the exam (*M* = 1.89) versus the lecture immediately prior (*M* = 1.78; *b* = .11, 95% CI [-.46, .67], *t* = .37, *p* = .71). As such, it appears that the observed increase in seating distance is only associated with the last day of classes, rather than any differences in seating patterns chosen between exam and non-exam classes.

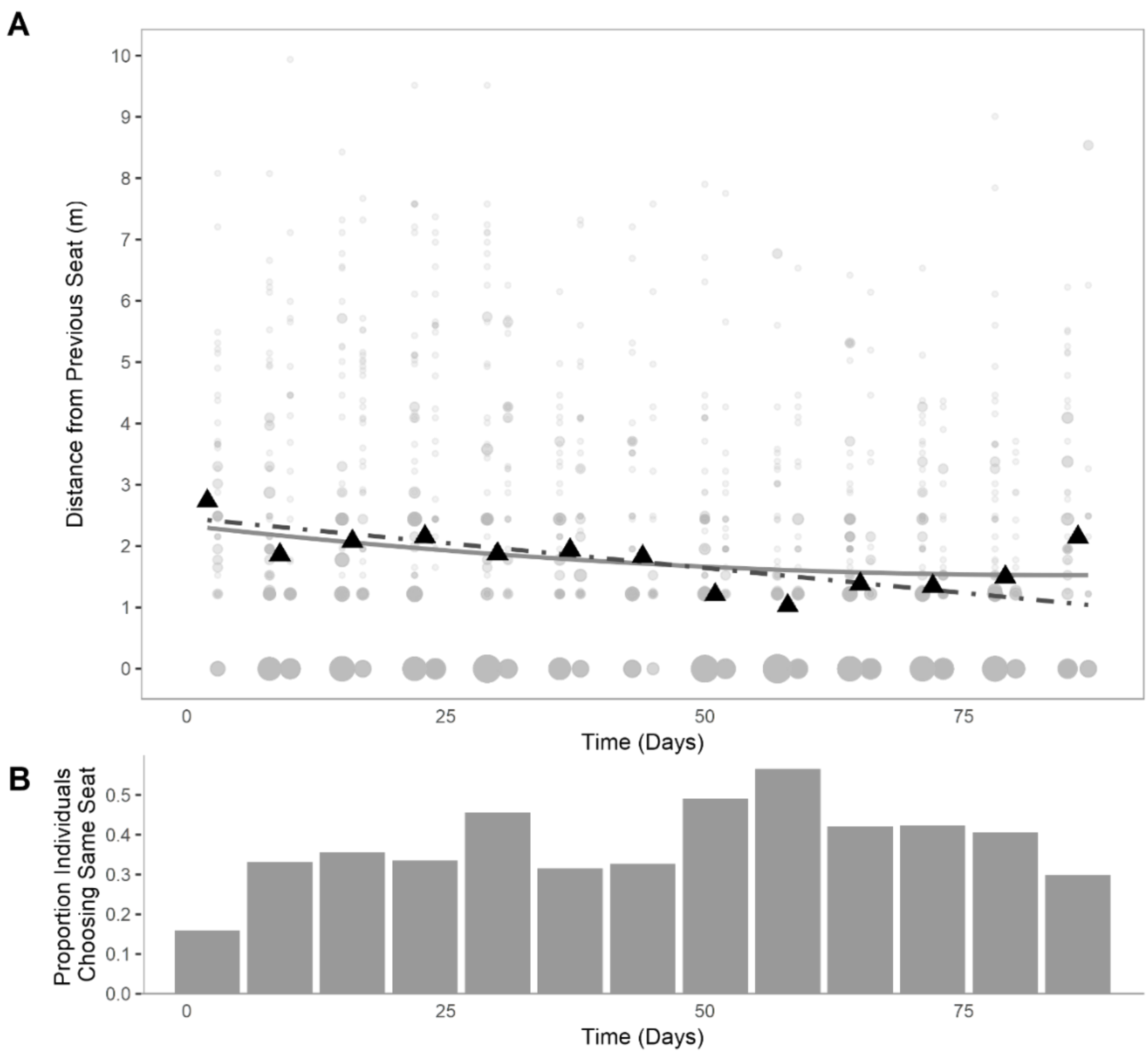


Figure 2. Distance between seating choice (A) and whether individuals moved seats (B) on two adjacent days as a function of time across all courses. For Figure 2A, black triangles represent mean distance between seats for classes averaged across a given week. The size of each point in the scatterplot increases as a function of the number of observations associated with that point. Solid grey lines represent the curvilinear trendline between time and seating distance in the full data set, and dotted black lines represent the linear trendline after data points from the final day of each course was removed. For Figure 2B, the proportion of individuals choosing the same seat on any given week is plotted as a function of time.

Discussion

I set out to extend current understanding of spatial decisions by examining the role of spatial habit in a naturalistic context (i.e., seating selection in classrooms). In the current study, I identified three factors that influenced individuals' spatial decisions. Firstly, individuals' past seat selection influenced future seating choice, providing strong corroborating evidence that spatial habit plays an important role in spatial decisions. Secondly, order of arrival appears to provide a barrier towards expressing or developing one's spatial habit, as latecomers tended to choose seats located further away from where they sat in the class immediately prior. Finally, I observed an unexpected disruption in seating choice near the end of the courses, as shown in the curvilinear relation between seating distance and time. Importantly, this curvilinear effect does not appear to be driven by differences in seat selection during lectures versus exams; rather, it appears to be a result of an increase in seating distance between the final day of class and the lecture immediately preceding it. As such, the observed curvilinear pattern may have resulted from two different effects: one that helps to stabilize spatial decisions over time (i.e., spatial habit), and one that leads to a de-stabilization of those same spatial choices. I discuss each of these three factors in more detail below.

Primarily, the current study provides evidence beyond laboratory studies (e.g., Zhu & Risko, 2016) that spatial habit plays an important role in naturalistic spatial decisions such as choosing where to sit in a class over the course of a semester. This is demonstrated by the finding that up until the last day of classes, the data exhibited a robust linear relation between seating choice and time. Specifically, there was an increase in the proportion of individuals who chose to sit in the same seats over time, as well as a decrease in seating distance between adjacent classes for individuals who did not sit in the same seats (perhaps because their preferred seats had been taken by someone else). This observed stabilization of seating choice across time is consistent with a habit formation account (Lally, Chipperfield, & Wardle, 2008; Neal, Wood, & Quinn, 2006) wherein individuals form an increasingly strong association between recurring contextual cues related to the class they attend (e.g., time of day, individuals present in the room, etc.) and particular behaviours (i.e., choosing which seats to sit in), and that this association is reinforced with repetition.

Order of arrival, on the other hand, may either help to facilitate or hinder spatial habits. For individuals with readily formed spatial habits, later arrival within a given class session could limit the expression of those habits. As more individuals arrive in the classroom, fewer seats become available. While those who arrive early to class may be able to express their spatial habits by choosing their preferred seats, latecomers can only choose from the limited number of unoccupied seats, and are, therefore, making seating choices based on availability rather than preference, as their preferred seats may be occupied. In other words, even if an individual has formed a moderate or strong spatial habit, they must also arrive relatively early to ensure that they are able to choose their desired seats. Across a longer time span, consistency in when individuals arrive to class can also undermine the formation of spatial habits. Individuals who consistently arrive early to class may be able to develop spatial habits at a much faster rate than those who consistently arrive late, since they are more likely to be able to consistently choose their preferred seats over time. Those who consistently arrive later in class may have little control over which seats to choose from, and the location of available seats could vary from class to class, making it difficult to consistently choose the same ones across a semester and form strong spatial habits.

Intriguingly, individuals' spatial habits seemed to dissipate near the very end of a course, as demonstrated by a marked increase in seating distance between the last day and the class before. Although it is unclear why this pattern of behaviour emerged, it is clear that the destabilizing effects observed in the study are not due to differences between lecture and exam sessions, but rather the termination of the course itself. I offer two potential explanations as to why this effect may have emerged in the current context. One explanation is that individuals on the last day may experience a substantial shift in mental context brought on by the termination of one's expectation to return to a given environment in the immediate future. As a result of this context shift, cues associated with eliciting one's spatial habit may be obscured, thus reducing the influence of spatial habit on one's seating choices. In contrast with this idea, it is possible that the de-stabilization in individuals' seating pattern could reflect the changing weights associated with the multiple factors likely contributing to individuals' spatial decisions. That is, there is at least one other factor influencing individuals' spatial decisions, which does not directly alter or act on the strength of one's spatial habit. For instance, this force could work in the same direction as spatial habit (i.e., biasing individuals to select the same seat when provided with the opportunity to do so) and diminish in strength upon approaching the end of a course (e.g., a lack of need to signal one's ownership over a given space). However, more work is needed to distinguish between these two potential mechanisms.

In summary, the current study set out to understand spatial decisions in a more complex, naturalistic environment. Together, results suggest that although spatial habit plays a crucial role in shaping individuals' spatial decisions over time, it may weaken once individuals no longer expect to occupy that space in the future. Though the present study provided corroborating evidence of the role of one's spatial habit in determining future spatial decisions, it also identified factors that may have otherwise been overlooked in experimental settings and highlighted the importance of using real-world approaches to complement and validate lab-based findings.

Chapter 3

In Chapter 1, it was found that where individuals chose to situate themselves in a space became more fixed over time, reflecting a kind of spatial habit formation within that space. That is, when individuals occupied a space relatively permanently, their spatial habits determined—to an extent—*where* to place themselves or objects in the environment. However, there are also many instances in real-world situations in which we do not try to maintain an object's location in space, opting instead to rearrange the objects in that space. Based on previous work, individuals are likely to preserve an object's location in space, unless it becomes sufficiently effortful for individuals to interact with it (Solman & Kingstone, 2017a; Zhu & Risko, 2016). In other words, performance-based considerations may lie at the heart of an individual's decision to organize their spaces when they are provided with the opportunity to do so. As such, the research goal of Chapter 2 is to determine the kinds of performance-related factors that may lead individuals to organize or rearrange their environments. I began this investigation by examining the likelihood that individuals would incorporate an organization-based search strategy in a real-world search task involving Lego building blocks.

Although performance accuracy or error has been an integral aspect of strategy selection in a variety of contexts (Lemaire & Reder, 1999; Lieder & Griffiths, 2017; Payne, Bettman, & Johnson, 1988; Siegler & Lemaire, 1997), these aspects of performance consideration may be less relevant when it comes to real-world search tasks using different strategies. Specifically, spatial organization does not often affect how accurately an item may be located in the context of a search task; rather, it affects the amount of time it would take an individual to locate a given object. Moreover, the maintenance or reorganization of items in space also require time. As such, individuals may select an organization-based search strategy (or choose against doing so), depending on whether doing so would result in faster task completion. Indeed, the tendency to minimize task time appears to be a well-accepted phenomenon within the strategy selection literature, in that individuals' behaviours tend to be better explained using models incorporating a time-minimization component compared to models that do not. (Gray & Boehm-Davis, 2000; Gray & Fu, 2004; Gray, Sims, Fu, & Schoelles, 2006).

Study 2

In Study 2, participants were asked to search for a subset of target pieces among a large pile of Lego building blocks. Before the task, participants were asked whether they would prefer to organize the pile before beginning the search task (e.g., categorizing based on colour or by shape) or to proceed directly to completing the search task. After making this decision, participants were asked to provide time estimates for how long they expected to take to complete the task both with an organization strategy and without. If individuals' preferences were based on the perceived costs and benefits involved in the strategies available, then I would expect them to prefer an organization strategy only when they expect it to take less time, and vice versa. During the task, participants were assigned to use either an organization- or non-organization-based search strategy, regardless of their stated strategy selection earlier. Importantly, in contrast with previous experiments that examined strategy selection where one strategy would be objectively more efficient (e.g., Lieder & Griffiths, 2017; Zhu & Risko, 2016), the task was constructed such that participants would complete the task using roughly the same amount of time regardless of which strategy was used. As such, this allowed us to infer whether individuals hold any systematic preference towards one of the two strategies. In addition to examining individuals' preference pre-task and measuring performance during the task, I also asked participants a number of follow-up questions in an attempt to gauge their experience during task performance, and whether experience with the task altered the perceived utility of each strategy. Under a time-minimization framework, I would expect individuals to choose the strategy that is perceived to take less time to complete the search task.

Method

Participants

I recruited a total of 53 students (37 female) from the University of Waterloo to participate in this study for course credit. This sample size was determined to ensure that a minimum of 20 participants would be assigned to use each search strategy in order to determine whether task completion time was equal across strategies. The mean age of this sample was 20.83 years (*SD* = 1.31); all participants reported normal or corrected-to-normal vision. All participants in the reported study provided informed consent prior to the study and were debriefed about the purpose of the studies upon completion. Ethical approval was obtained from the University of Waterloo Research Ethics Board.

Design

Participants were randomly assigned to use one of two strategies (organization-based or search-only strategy) in a between-subjects design. However, it should be noted that the random assignment of strategy was not a key variable in the study, as the focus was on relating individuals' perceived task time to their strategy selection both pre- and post-task.

Materials & Procedure

At the start of the study, participants were told that they would be completing a search task that involved searching for a subset of target pieces among a pile of Lego building blocks. They were then presented with the pile in front of them (see Figure 3A), which had a total of 483 pieces, as well as the instruction cards with the relevant pieces that they would be searching for (see https://www.lego.com/en-ca/themes/classic/building-instructions/10696 for examples of the instruction cards), consisting of a total of 161 target pieces. These target pieces were pieces that made up of structures as shown in Figure 3B. Importantly, participants were strictly told that they were only to search for the relevant pieces, and that they must not construct the Lego structures as presented on the instruction cards.

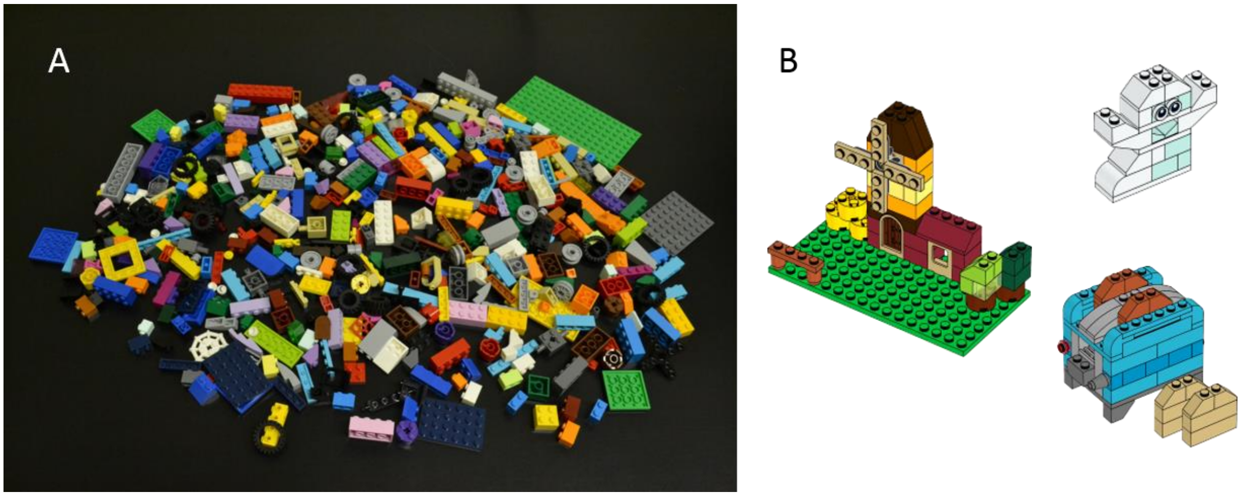


Figure 3. Lego stimuli used in the task. (A) Lego pile that participants were shown at the start of the experiment. (B) Structures that the target pieces would contribute towards, if they were to be built.

After an overview of the task was provided, participants were told that they would be using one of two strategies to search for the target pieces—to (i) directly search for the target pieces without any spatial organization or (ii) to organize the pile into categories based on some form of external feature (e.g., colour or shape) and then search for the target pieces—and they were asked to select which strategy they would prefer to use for this task. This question would be followed up by having participants verbally describe why they chose this particular strategy and their response was recorded by the experimenter. Then, participants were asked to estimate how long it would take them to complete the task for each of the two strategies. For the organization strategy, the estimated task time was broken into the amount of time they expected to spend on organization only, and the amount of time they expected to search for the pieces only; for the search-only strategy, only the total search time was provided.

After participants provided their strategy selection and respective time estimates, they were randomly assigned to complete the search strategy using one of the two strategies presented to them earlier. At this point, the experimenter provided more detailed instructions for completing the search task. Those assigned to the organization strategy were told that they must complete the task in sequence such that they must organize all of the pieces into colour categories before moving on to the search task. Note that individuals were only provided with the criterion of forming colour categories and were free to form as many or as few colour categories as they wished. On the other hand, those assigned to complete the search using the search-only strategy were told they must not form any systematic categories while they search for the pieces. The experimenter left the room while participants completed the search task; to measure objective task time and to ensure compliance, a GoPro HERO3 was mounted onto the wall to provide a bird's eye perspective of the task space and was used to record participants' performance throughout the study.

Once participants completed the search task, they were asked to provide a time estimate for how long it took them to complete the task using the assigned strategy, as well as how long they thought it would take them using the alternate strategy that they were not assigned, similar to that in the pre-task. The estimate for the organization strategy was again broken down into the amount of time they expect to spend on the organization and search phase separately once a total estimate was provided. Following task time estimates, I also asked participants to describe the exact strategy they used when completing the search task to ensure that participants completed the task according to the instructions. I also asked them whether, given their current experience with the task, they would continue to use the same strategy they were assigned in the future as a measure of their updated strategy selection post-task. If participants answered no to this question, I asked them to elaborate and describe their preferred alternative strategy. Finally, participants were probed for suspicion regarding the purpose of the experiment before being debriefed.

Results

Though I included data from all individuals for their pre-task responses, 12 individuals' objective task time and post-task responses were removed from analyses due to equipment failure during the search task (7) or improper task completion (e.g., built the Lego structures while looking for the pieces, sorted pieces based on shapes instead of by colour, etc) (5). Unless noted otherwise, the pattern of results remained the same when these subjects were removed from post-task analyses. All analyses were conducted using R (R Core Team, 2019). In addition to *p*-values, I report Hedges's *g* using the *effsize* package (Torchiano, 2019) as a measure of effect size for two-group comparisons wherever appropriate. For logistic regressions, the 95% likelihood ratio confidence interval for each estimate was reported (Meeker & Escobar, 1995), as extracted using the *sjPlot* package (Lüdecke, 2018). The formatting of summary tables was also done using the *sjPlot* package. Note that Tjur's R^2, or coefficient of determination, is generally used as a pseudo-R^2 measure for generalized linear models that deal with binary outcome variables and can be interpreted similar to R^2 (Tjur, 2009).

Objective Task Time

Individuals assigned to the search-only strategy spent 28.90 minutes (*SD* = 6.65) on average completing the task, while those assigned to the organization strategy spent 28.03

minutes (*SD* = 8.70). Task completion time was not statistically significant, as indicated by a Welch's two-sample t-test, $t(35.57) = .36$, $p = .72$, $g = 0.11$. On average, those assigned to the organization strategy completed the organization phase in 13.33 minutes (*SD* = 8.05).

Estimated Task Completion Time

I compared individuals' estimated task time for each strategy prior to the start of the task using a paired-sample t-test. There was no significant difference between the overall task time estimates provided for search-only strategy (*M* = 28.07, *SD* = 13.80) versus the organization strategy (*M* = 30.13, *SD* = 17.57; $t(52) = 1.35$, $p = 0.18$, $g = .12$)[1]. The mean estimated time for completing the organization phase was 12.38 minutes (*SD* = 7.87).

As with the pre-task time estimates, there was also no significant difference between overall time estimates provided for the search-only (*M* = 33.98, *SD* = 11.53) and the organization strategies (*M* = 31.49, *SD* = 13.31) when participants were asked to provide these estimates again post-task, $t(40) = 1.04$, $p = .30$, $g = .20$. The organization phase was estimated to take 15.22 minutes (*SD* = 9.65). Figure 4 provides a visual comparison of both the objective task completion time for each strategy, as well as individuals' perceived task time for each strategy pre- and post-task.

For descriptive purposes, of the 53 total participants, 20 perceived an organization strategy to be faster, 25 perceived the search-only strategy to be faster, and the remaining 8 perceived the two tasks to take the same amount of time. Post-task, 27 out of 41 participants perceived the organization strategy to be faster, 10 perceived the search-only strategy to be faster, and 4 perceived them to take the same amount of time.

[1] When I removed data from the same 12 subjects who were removed from post-task analyses, there was a marginally significant difference between the estimates, with the search-only strategy being rated as being slightly faster (*M* = 28.78, *SD* = 14.53) than the organization strategy (*M* = 32.12, *SD* = 19.05, $t(40) = 1.81$, $p = .08$, $g = .18$).

Figure 4. Objective task completion time as a function of assigned strategy (left) and estimated task time using either strategy (center and right) in Study 2. Error bars represent 95% confidence intervals.

Strategy Selection

Pre-Task Choice. First, given that objective task completion was the same across strategies, I examined whether individuals had any systematic preferences for a given strategy pre-task. As shown in Figure 5, the majority of individuals (73.6%) preferred the search-only strategy over organization, which was statistically different from chance, $\chi^2(1, N = 53) = 11.79$, $p < .001$.

Next, I examine whether participants' chosen strategies were predicted by the set of time estimates they provided. As mentioned previously, though overall time estimates provided for each strategy do not differ overall, it is possible that *relative* time difference across strategies provided by each individual may drive their strategy selection. To do so, I took the difference between the time estimates provided between the two strategies (i.e., time estimate for the search-only strategy minus that of the organize-first strategy) and used this difference score in a logistic regression model to predict whether individuals were more likely to choose an organize-first (coded as 1) or a search-only strategy (coded as 0). As such, a positive difference score would indicate that the organize-first strategy was thought to have taken less time, and vice versa. As shown in Table 5, results from this model supported previous predictions; the less time individuals rated the organize-first strategy to take relative to the search-only strategy, the more likely they were to pick the organize-first strategy, b = .12, 95% CI [.03, .20], z = 2.69, p = .01. However, the intercept remained significant in the model, demonstrating that even when there was no difference in estimated task time between each strategy, individuals still had a preference for the search-only strategy, b = -1.11, 95% CI [-1.90, -.44], z = 3.05, p < .001.

Post-Task Choice. In addition to pre-task strategy selection, I also examined strategy selection post-task. Participants were asked post-task whether they would use the same strategy as the one they were assigned pre-task, and if not, to describe the alternative strategy they would use, and their responses were coded. All participants provided either a search-only strategy or a strategy that incorporated organization (e.g., organizing pieces by shape instead of by colour). Surprisingly, whereas individuals preferred a search-only strategy pre-task, this preference was reversed post-task such that most individuals (68.3%) preferred an organization strategy overall, $\chi^2(1, N = 41) = 5.49$, p = .02 (see Figure 5).

Using the difference score between the time estimates provided post-task, a logistic regression revealed that time estimates significantly predicted post-task strategy selection. As with pre-task time estimates, there was a positive relation between the difference score in time estimates and post-task choice, *b* = .07, 95% CI [.02, .13], *z* = 2.54, *p* = .01. However, when relative time difference was 0, results showed a marginally significant intercept, *b* = .72, 95% CI [-0.00, 1.50], *z* = 1.92, *p* = .06, indicating that there was a slight preference for the organization strategy.

Table 5.

Logistic regression model using relative task time to predict individuals' strategy selection both pre- and post-task completion in Study 2.

	Pre-Task			**Post-Task**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	-1.11	-1.90 – -0.44	**0.002**	0.72	-0.00 – 1.50	0.055
Relative Time	0.12	0.04 – 0.21	**0.007**	0.07	0.02 – 0.14	**0.011**
Observations	53			41		
R^2 Tjur	0.171			0.201		

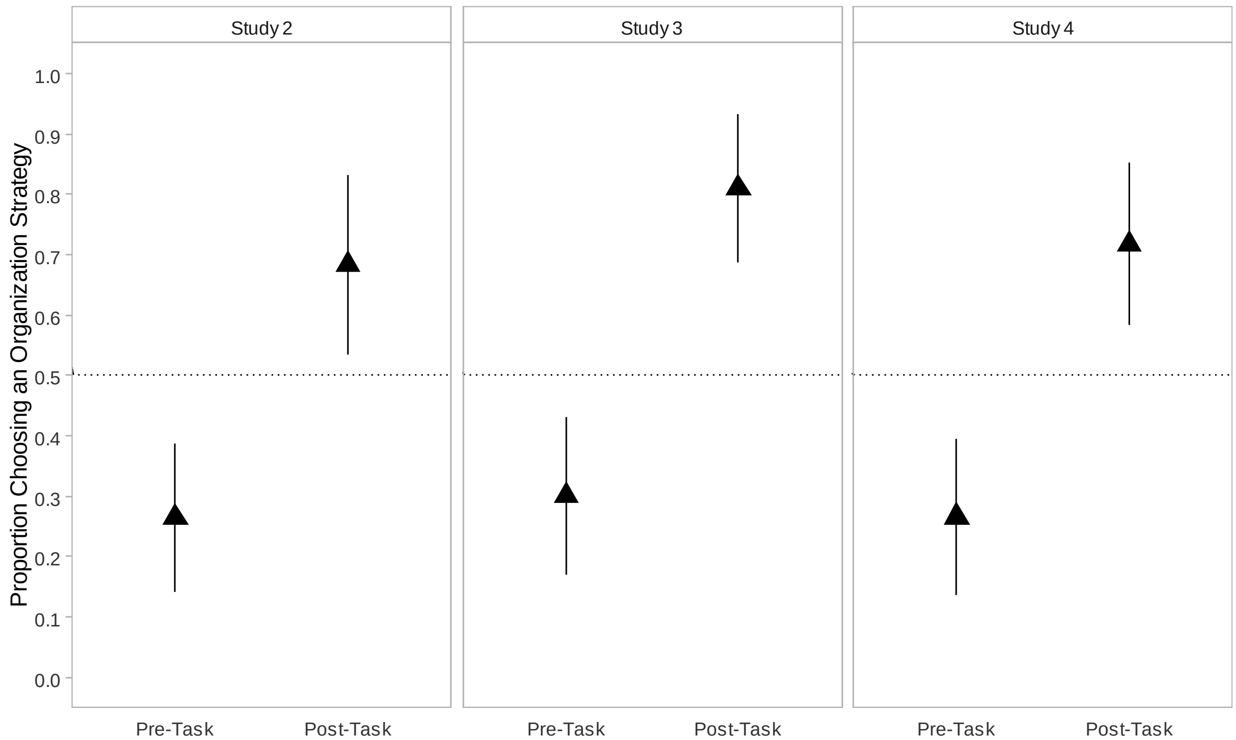


Figure 5. Mean proportion of individuals who preferred an organization strategy pre-task in Studies 2-4. Error bars represent 95% confidence intervals.

Discussion

In Study 2, participants overwhelmingly preferred a search-only strategy prior to engaging in the task, even though participants would be no faster at completing the search task using such a strategy. Strategy selection was driven, in part, by participants' estimated task time, with individuals preferring the strategy that they thought would take the least amount of time. However, task time considerations did not completely explain strategy selection given that participants were still more likely to choose the search-only strategy even when the estimated task time did not differ (via statistically controlling for time) between the two strategies. Post-task, participants' strategy selection reversed such that they preferred an organization strategy.

These preferences were again predicted by relative task time, with individuals preferring the strategy that they perceived to be faster. The intercept was, however, marginally significant in the model, with individuals preferring the organization strategy even when the two strategies were estimated to take the same amount of time.

Given that relative task time significantly predicted individuals' strategy selection both pre- and post-task, these results lend support to the time-minimization hypothesis that individuals would choose the strategy that is expected to take less time. However, the observed strategy selection in both cases were not fully explained by this factor, with individuals showing an initial bias against a search strategy that involved organization and later, a (marginal) reversal in strategy selection post-task. These preferences are especially interesting, as participants' performance using randomly assigned strategies showed that they were no faster at completing the search task regardless of which strategy was used. In Study 3, I attempt to replicate these results and further examine why these biases in strategy selection may have emerged.

Study 3

In Study 2, I found that individuals preferred whichever strategy was thought to minimize perceived task time. However, the perceived time costs associated with each strategy could not entirely explain the observed preference for directly searching for the target pieces prior to engaging in the search task, nor the post-task preference switch. The goal of the current study was to attempt to gain a better understanding of why individuals exhibited these kinds of systematic biases in their strategy selection, focusing on examining the systematic preference against organization pre-task.

One possible reason for the reported pre-task preference to directly search for the target pieces may reflect a desire to progress continuously in the task space, as opposed to delaying progress on the primary task (i.e., search) until after a period of organization. Although spatial organization can allow certain objects or information to become more salient in the environment (Kirsh, 1995) and lead to accelerated progress in the primary task (e.g., search), the act of organization in and of itself could be argued to not *directly* bring individuals closer to completing said task (e.g., finding items in the search task). For example, individuals who organize their closet systematically will allow them to locate individual clothing items more easily when they go to search for them in the future. However, the act of organizing one's closest in and of itself does not lead to progress in the future search task but merely facilitates it. In the context of the current studies, participants assigned to the organization strategy were required to organize all of the Lego pieces prior to engaging in search. As such, participants may anticipate a lack of progress at the start of the task. If this is the case, this perceived lack of progress may have contributed to the observed tendency for individuals to avoid choosing an organization strategy pre-task. Thus, in Study 3, I looked to assess how individuals perceived their progress across the search- and organization-based strategies in order to understand the systematic bias observed in individuals' strategy selection pre-task. If participants' perceived task progress reflects their objective progress on the primary search task, then I would expect individuals' reported task progress to be relatively linear as a function of time for those assigned to the search-only strategy. On the other hand, I expect individuals assigned to complete the task using the organization strategy to show a non-linear pattern in their self-reported task progress. Specifically, I would expect little to no perceived progress in the task during the initial organization phase, and accelerated progress during the later search phase (see Figure 6 for a visual depiction of this prediction).

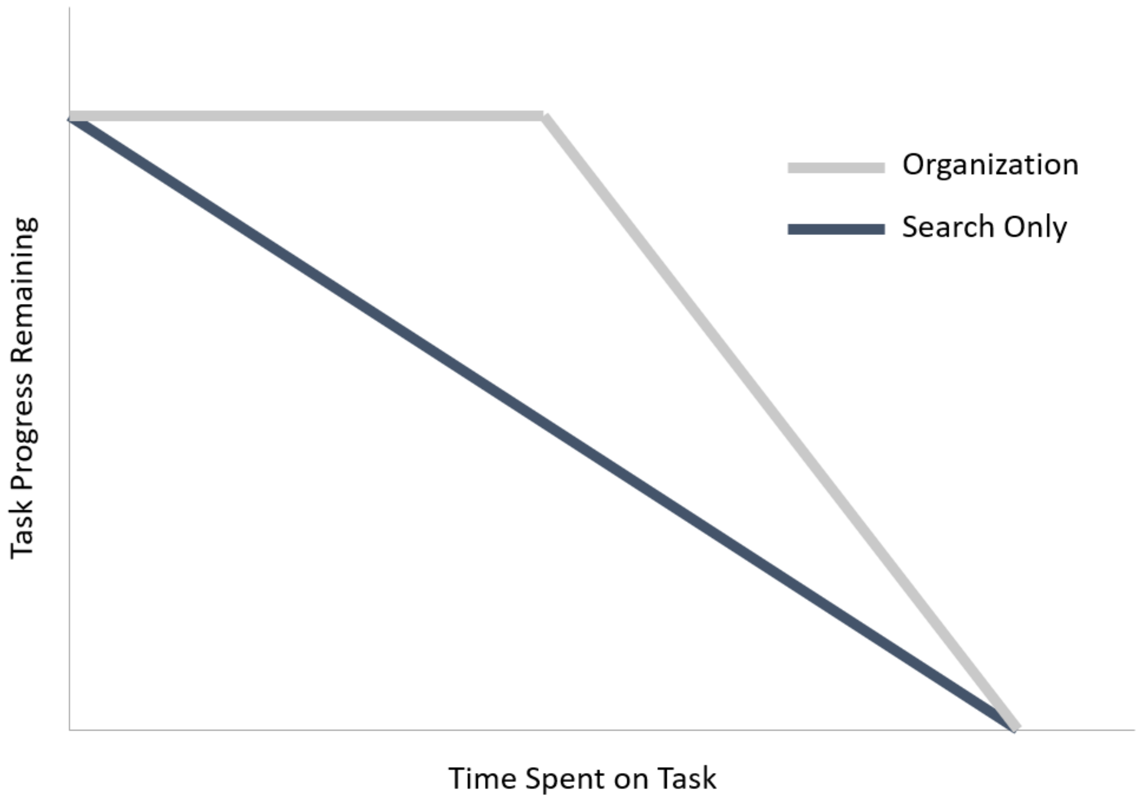


Figure 6. Predicted perceived task progress remaining on the search task as a function time spent performing the task for both the search-only (black line) and organization strategy (grey line).

Method

Participants

A total of 50 students (37 female) from the University of Waterloo were recruited to participate in this study for course credit. The mean age of this sample was 20.06 years (SD = 2.71); all participants reported normal or corrected-to-normal vision.

Design

Participants were randomly assigned to use one of two strategies (organization-based or search-only strategy) in a between-subjects design. Participants responded to voice prompts between 3 to 9 times when performing the search task.

Materials & Procedure

In Study 3, participants were provided with voice prompts during the assigned search task using PsychoPy (Peirce et al., 2019) on a Windows PC. The prompts directed participants to stop what they were doing and to orally respond, in minutes, how much time they thought was still needed to complete the task. After a 3 second response window, participants were given a separate prompt that asked them to resume their task. Prompts were delivered at pseudo-random time points within a 5-minute interval, ensuring that participants would be provided with a prompt every 5 minutes on average, until they have completed the search task. As measuring subjective progress of time was critical in the current experiment, participants were told to put away their cellphones and watches at the start of the experiment. With the exception of added voice prompts throughout the experiment, the procedure was identical to that of Study 2.

In order to mitigate technical issues I encountered with the previous recording device and to enhance video quality, I switched the recording device to a 1080HD Logitech C920.

Results

As with Study 2, I removed 8 participants' objective search time as well as their responses during and post search from analyses due to equipment failure (2), improper task completion (e.g., built the Lego structures while looking for the pieces, sorted pieces based on shapes instead of by colour, etc) (4), or task incompletion (2). Unless otherwise noted, the pattern of results remained the same when these subjects were removed from analysis.

I used the *lme4* package in R (Bates et al., 2015) to conduct mixed-effects model analyses when the same individuals made multiple responses (e.g., making multiple task time estimations across an experiment) using the default optimizers. I opted for more complex random effects structures (e.g., allowing both the intercept and slopes to vary per individual, as opposed to just the intercept) when there were sufficient observations in the data set for the model to converge, and when doing so improved the model fit (Bates, Kliegl, Vasishth, & Baayen, 2018). In cases where models failed to converge but the gradient was sufficiently small (i.e., $< .002$), I increased the number of iterations from the default 10000 to 30000. As degrees of freedom for mixed-effects models can be difficult to estimate, p-values are approximated using Wald z-statistics, and 95% Wald confidence intervals are reported and were extracted using the *sjPlot* package (Lüdecke, 2018).

Objective Task Time

A Welch's two-sample t-test indicated that individuals assigned to the search-only strategy (M = 26.28, SD = 6.92) took just as long as those assigned to the organization strategy (M = 26.91, SD = 6.38; $t(39.99) = .31$, $p = .76$, $g = 0.09$). On average, individuals spent 11.86 minutes (SD = 3.26) in the organization phase.

Estimated Task Completion Time

Figure 7 provides a visual depiction of the results. A paired-samples t-test found no difference in overall time estimates provided for the search-only (M = 28.42, SD = 11.12) and organization strategies (M = 27.78, SD = 11.50; $t(49) = .53$, $p = .60$; $g = .06$) prior to the search task. The average estimated completion time for the organization phase was 11.16 minutes (SD = 5.54). However, post-task, individuals estimated that the search-only strategy (M = 31.52, SD = 10.00) would take significantly longer than the organization strategy (M = 26.5, SD = 7.67; t(41)

= 4.08, $p < .001$; $g = .54$). The organization phase was estimated to take 11.56 minutes (*SD* = 5.33).

Of the 50 participants in this sample pre-task, there were 23 who perceived that an organization strategy would result in faster task completion, 18 who perceived that the search-only strategy would be faster, and the remaining 9 perceived the two strategies to take the same amount of time. Post-task, 28 of the 42 participants estimated that the organization strategy would be faster, 7 perceived that the search-only strategy would result in faster task completion, while 7 estimated that they would take the same amount of time.

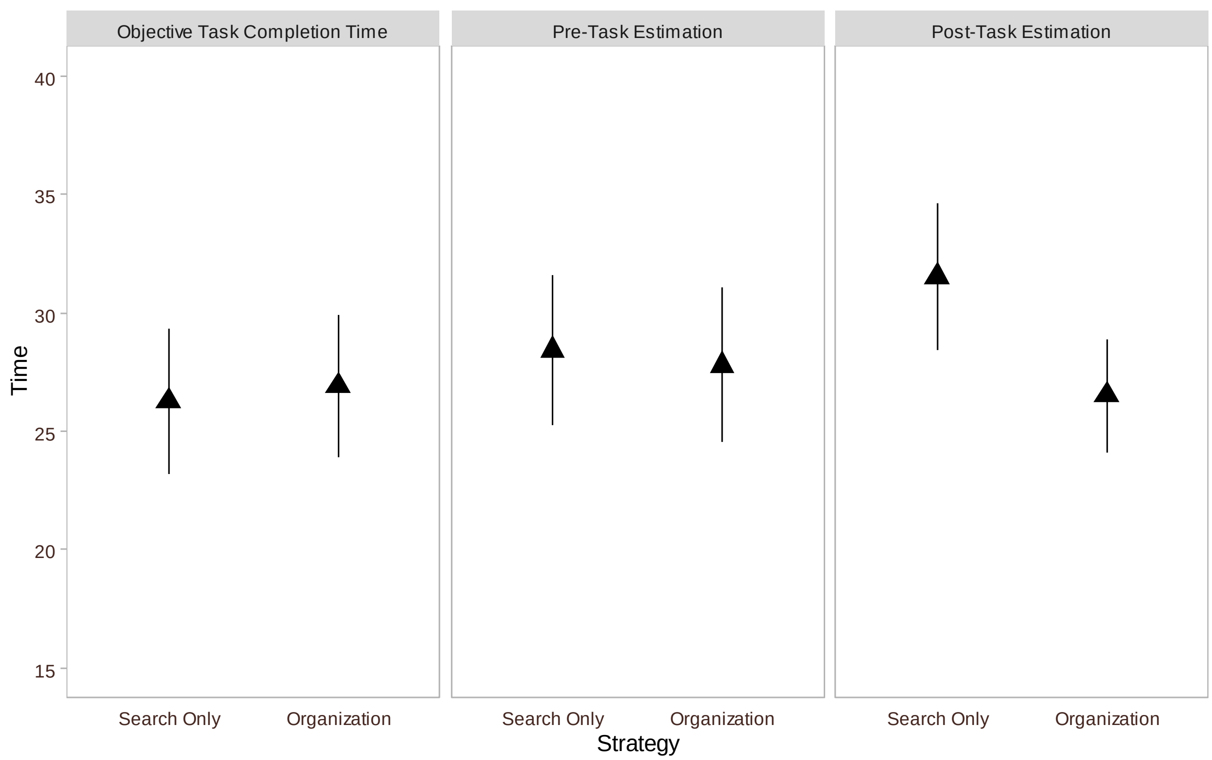


Figure 7. Objective task completion time as a function of assigned strategy (left) and estimated task time using either strategy (centre and right) in Study 3. Error bars represent 95% confidence intervals.

Strategy Selection

Pre-Task Choice. As with Study 2, the majority of individuals (70.0%) preferred the search-only compared to the organization strategy, $\chi^2(1, N = 50) = 8$, $p = .005$ (see Figure 5). A logistic regression indicated that the likelihood of selecting an organization strategy increased if it was expected to take less time compared to the search-only strategy, $b = .20$, 95% CI [.09, .36], $z = 3.05$, $p < .001$. However, even accounting for relative task time, there was still an overwhelming preference for the search-only strategy as indicated by the significant intercept in the model, $b = -1.38$, 95% CI [-2.37, -.60], $z = 3.13$, $p < .001$.

Post-Task Choice. Post-task, 81.0% of individuals preferred an organization strategy overall, $\chi^2(1, N = 42) = 16.10$, $p < .001$ (see Figure 5). However, a logistic regression using relative estimated task time as a predictor did not significantly predict post-task choice, $b = .07$, 95% CI [-.03, .17], $z = 1.37$, $p = .17$, and the intercept remained significant, $b = 1.19$, 95% CI [.39, 2.08], $z = 2.81$, $p < .001$. The results of the logistic regression models for both pre- and post-task strategy selection are shown in Table 6.

Table 6.

Logistic regression model using relative task time to predict individuals' strategy selection both *pre- and post-task completion in Study 3.*

	Pre-Task			**Post-Task**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	-1.38	-2.37 – -0.60	**0.002**	1.19	0.39 – 2.08	**0.005**
Relative Time	0.20	0.09 – 0.36	**0.002**	0.07	-0.03 – 0.17	0.172
Observations	50			42		
R^2 Tjur	0.311			0.040		

Perceived Task Progress

Critical to the notion that individuals perceive progress differently when using a search-only versus organization strategy is that the former should exhibit a relatively linear relation between actual and self-reported task progress, whereas the latter is expected to be non-linear (i.e., that there would be little perceived task progress during the organization phase of the task). Given that the critical dependent variable is task time remaining, I predict that a concave quadratic equation should better fit the data.

To test this idea, I constructed a linear mixed-effects model using maximum likelihood estimation. In order to account for the fact that some participants completed the task more quickly than others, I divided the time that a given prompt was delivered to participants by the objective task completion time to derive a more standardized measure of time on task. As such, assigned task strategy (search-only vs organization), the first and second-order polynomial term of proportion time on task, as well as the interaction term between the second-order polynomial and assigned strategy, were included as predictors, and individuals' estimated completion time was used as the criterion variable. Since an interaction is included in the model, continuous predictors were mean-centered, and sum contrasts were reported for categorical predictors. After model comparison, I chose a model wherein I allowed only the intercept to vary per individual. Note that I do not report the estimate for the first-order polynomial term of standardized time on task in the current model, as it represents the instantaneous rate of change when the x-intercept is at 0. Figure 8 show a graph of the individuals' estimated completion time as a function of objective time. Estimated task completion time did not differ as a function of assigned strategy, $b = .81$, 95% CI [-1.12, 2.74], $t = .82$, $p = .41$. The second-order polynomial term of proportion time on task was not a significant predictor, *b* = -2.59, 95% CI [-12.55, 7.37], *t* = .51, *p* = .61, nor was there a significant interaction, *b* = -3.54, 95% CI [-13.47, 6.39], *t* = .70, *p* = .48.

I conducted follow-up analyses to examine whether there would be differences in the linear relation between perceived and actual time progress for each strategy. As such, a second set of linear mixed-effects models were conducted. After model comparison, I allowed both the intercept and slope for proportion time to vary for each participant, as there was considerable variability across individuals in their estimates across proportion of time on task ($\sigma^2 = 182.64$); this model also had a significantly better model fit than a model with just a random intercept structure, $\chi^2(2) = 83.98$, $p < 0.001$. Results showed that there was a significant linear relation between proportion time spent on task and estimated task time remaining, *b* = -21.86, 95% CI [-26.35, -17.37], *t* = 9.55, $p < .001$, though overall estimates did not differ as a function of assigned strategy, *b* = .81, 95% CI [-.91, 2.52], *t* = .92, *p* = .36. The interaction term was not a significant predictor, *b* = -3.84, 95% CI [-8.33, .65], *t* = 1.68, *p* = .09.

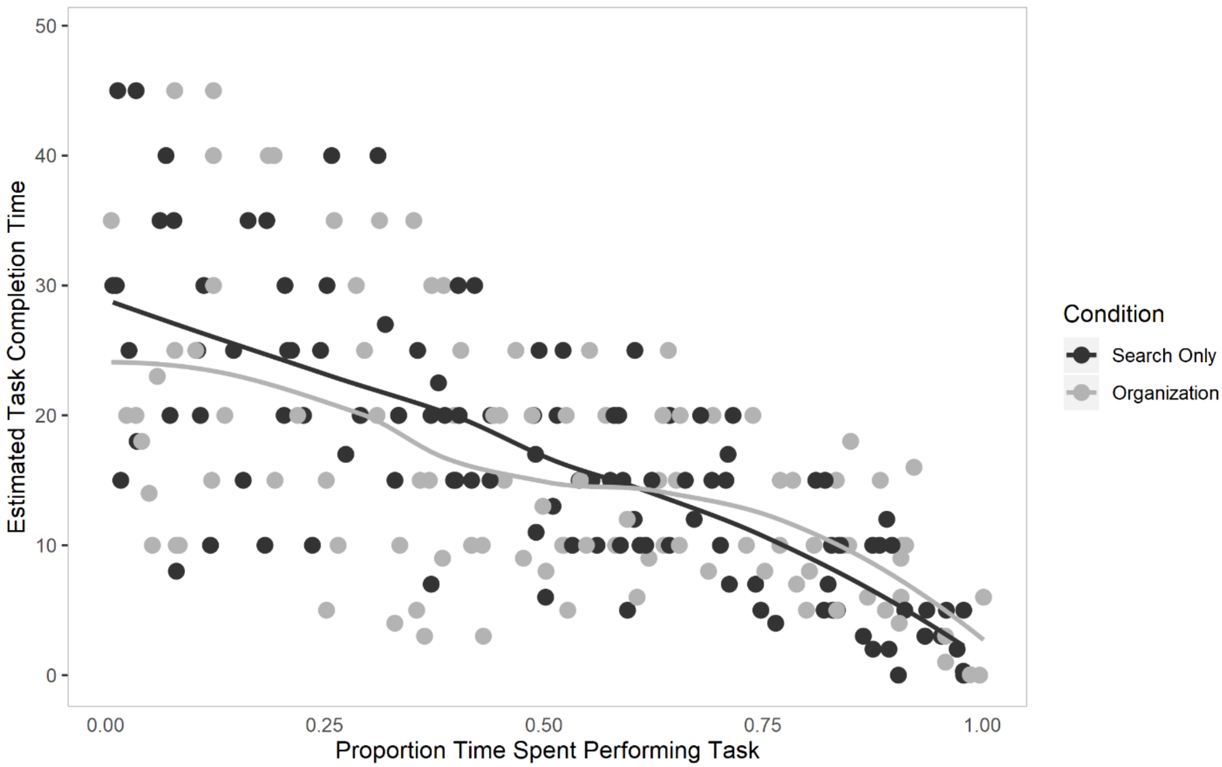


Figure 8. Estimated task completion time as a function of the proportion of time spent performing the Lego search task in Study 3. The darker data points represent participants' responses in the assigned search-only strategy. Solid lines show a best-fitting loess curve for each assigned strategy.

Discussion

In Study 3, I replicated the finding that prior to engaging in the task, individuals preferred strategies they thought would take less time overall. Again, this pre-task preference could also not be fully explained by relative task time estimates alone, given that individuals still preferred the search-only strategy when the relative task time difference was at 0. I also replicated individuals' strategy selection switch post-task, such that individuals overwhelmingly preferred an organization strategy. However, unlike in Study 2, relative task difference did not significantly predict strategy selection post-task. I also did not find evidence supporting the idea that perceived task progress—as measured by participants' estimated task time remaining—differed between assigned strategies. I address these results in detail below.

Although I found that relative task time explained individuals' pre-task strategy selection across both experiments, this relation was less clear post-task, with relative task time being a marginally significant predictor for post-task preference in Study 2 and a non-significant predictor in Study 3. It is possible that the current sample may have been underpowered to detect an effect with the number of individuals in each of the two samples. To address this, I pooled data across the two experiments and conducted a logistic regression with experiment (Study 2 vs. 3) and relative task time as well as their interaction term as predictors, and post-choice strategy selection as the criterion. Since an interaction term is included in this model, I report sum contrasts for categorical variables. Results show that with a combined sample ($N = 83$), relative task time was a significant predictor of post-task strategy selection, $b = .07$, 95% CI [.02, .13], $z = 2.47$, $p = .01$. Experiment did not significantly predict strategy selection across the two experiments, $b = -.33$, 95% CI [-.80, .32], $z = .82$, $p = .41$, nor did it interact with relative task time, $b = .003$, 95% CI [-.06, .06], $z = .11$, $p = .91$. Based on the pooled data, it appears that relative task time—both pre- and post-task—predicts individuals' chosen strategies.

Contrary to the prediction that individuals' perceived task progress differently when completing the task using the search-only vs. organization strategy, individuals assigned to the organization condition did not show a non-linear pattern in their reported time estimations. In fact, follow-up analyses indicated that individuals in both conditions showed a linear relation in their estimates over time. One possible explanation for the lack of difference in perceived task progress across the two strategies is that the measure of progress in this study (i.e., time) may not have captured the subjective experience of task progress accurately. Since individuals were asked to provide the amount of time they thought was remaining on the task—a rather indirect measure of perceived task progress—this may have inadvertently caused them to focus on how much time they have already spent on the entire task, rather than reflecting on the amount of progress they have made. In light of this possibility, I examine the perception of task progress across the different strategies in the next study by employing a more direct measure of perceived task progress.

Study 4

In both Studies 2 and 3, individuals generally tended to select whichever strategy helped to minimize task time. Perceived task time, however, only *partially* explained individuals' strategy selection pre- and post-task; even accounting for task time, individuals were still biased towards one preference or another. Notably, these results suggest that individuals' decision to engage in spatial organization may be influenced by factors other than time considerations. One interesting candidate in this respect is perceived task effort. Past literature has suggested that perceived task effort can be a strong driver of behaviour despite a lack of benefit in objective task performance (e.g., task accuracy; Risko et al., 2014). Though researchers have argued that individuals' tendency to minimize task time reflects a tendency to avoid effort (Gray & Fu, 2004; Gray et al., 2006), there is evidence to suggest that effort-based decisions need not be based on time costs associated with a task (Dunn & Risko, 2019). As such, I examine whether individuals' preferences for organization-based strategies are related to the perceived effort of the associated strategy. In addition to examining whether perceived task effort would influence search strategy selection, the current study also attempts to re-examine individuals' perception of task progress across the two strategies using a different approach. In the current experiment, I asked participants to indicate how much progress they think they have made on the task using a progress bar, rather than asking participants to provide verbal estimates of how much time they anticipate needing to complete the remainder of the task. Similar to the prediction made in Study 3, individuals assigned to use the search-only strategy should perceive a relatively linear relation between perceived progress and time spent on task; on the other hand, individuals who use the organization-based strategy should experience little to no progress during the organization phase, but perceived task progress should increase at an accelerated rate during the search phase of the task (see Figure 9).

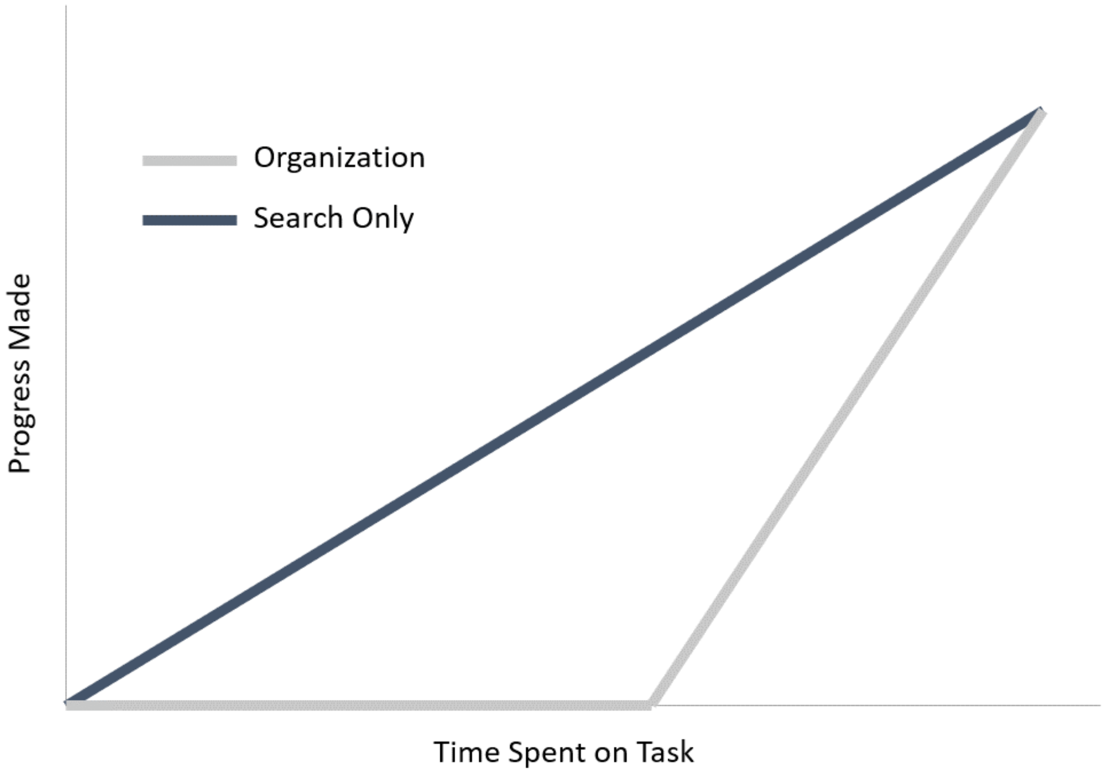


Figure 9. Predicted perceived progress made on the search task as a function of time spent performing the task for both the search-only (black line) and organization strategy (grey line).

Method

Participants

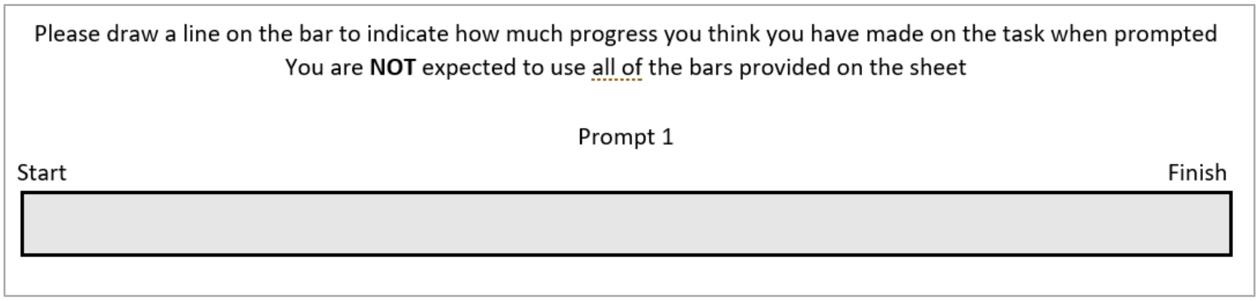
A total of 49 students (43 female; 1 unknown) from the University of Waterloo were recruited to participate in this study for course credit. The ages of 2 individuals were not reported. For the remaining sample, the mean age was 19.49 years (*SD* = 2.08); all participants reported normal or corrected-to-normal vision.

Design

Participants were randomly assigned to use one of two strategies (organization-based or search-only strategy) in a between-subjects design. Participants responded to voice prompts between 3 to 10 times when performing the search task.

Materials & Procedure

The overall task procedure was the same as in Studies 2 and 3. However, rather than asking participants to estimate how many minutes it would take to complete the task using each strategy, participants were asked to rate how effortful each strategy seemed on a 6-point Likert scale ranging from 1 (not at all effortful) to 6 (extremely effortful). Participants in Study 4 were also given voice prompts in the same manner as in Study 3, with the only difference between the content of the prompt. These prompts directed participants to stop what they were doing and to draw a vertical line on a progress bar printed on a letter sized piece of paper to indicate how much progress they think they have made in the task (see Figure 10 for an example of the progress bar). Participants in this study were also told to put away their cellphones and watches at the start of the experiment.


Please draw a line on the bar to indicate how much progress you think you have made on the task when prompted
You are **NOT** expected to use all of the bars provided on the sheet

Prompt 1

Start Finish

Figure 10. Progress bars and task instructions printed presented to participants. There were a total of 10 prompts printed across 2 sides of the sheet of paper.

Results

Analysis

Three participants' objective search time as well as their responses during and post search were removed from analyses due to equipment failure (1), improper task completion (e.g., built the Lego structures while looking for the pieces, sorted pieces based on shapes instead of by colour, etc) (1), or task incompletion (1). Unless indicated otherwise, the pattern of results remained the same when these subjects were removed from the analyses.

Objective Task Time

In examining objective task performance, a Welch's two-sample t-test confirmed that individuals assigned to the organization strategy (M = 29.44, SD = 5.00) took just as long as those assigned to the search-only strategy (M = 29.84, SD = 9.11), t(38.37) = .18, p = .86, g = 0.05. On average, individuals using the organization strategy spent 13.68 minutes (SD = 3.24) organizing the Lego pieces.

Estimated Task Effort

I found no difference in perceived task effort for the organization (M = 3.49, SD = 1.31) and search-only strategy (M = 3.90, SD = 1.10; t(48) = 1.48, p = .15; g = .33) prior to the search task using a paired-sample t-test. Interestingly, individuals rated the organization strategy as being more effortful (M = 4.39, SD = 1.44) than the search-only strategy post-task (M = 3.32, SD = 1.62; $t(45) = 4.06$, $p < .001$; $g = .74$; see Figure 11).

Pre-task, 26 of the 49 participants rated the organization strategy as being easier, 18 rated the search-only strategy to be easier, and 5 rated them as being equally effortful. Post-task, 12 of the 46 participants rated the organization strategy as being easier, 31 rated the search-only strategy as being easier, and 3 rated them as being equally effortful.

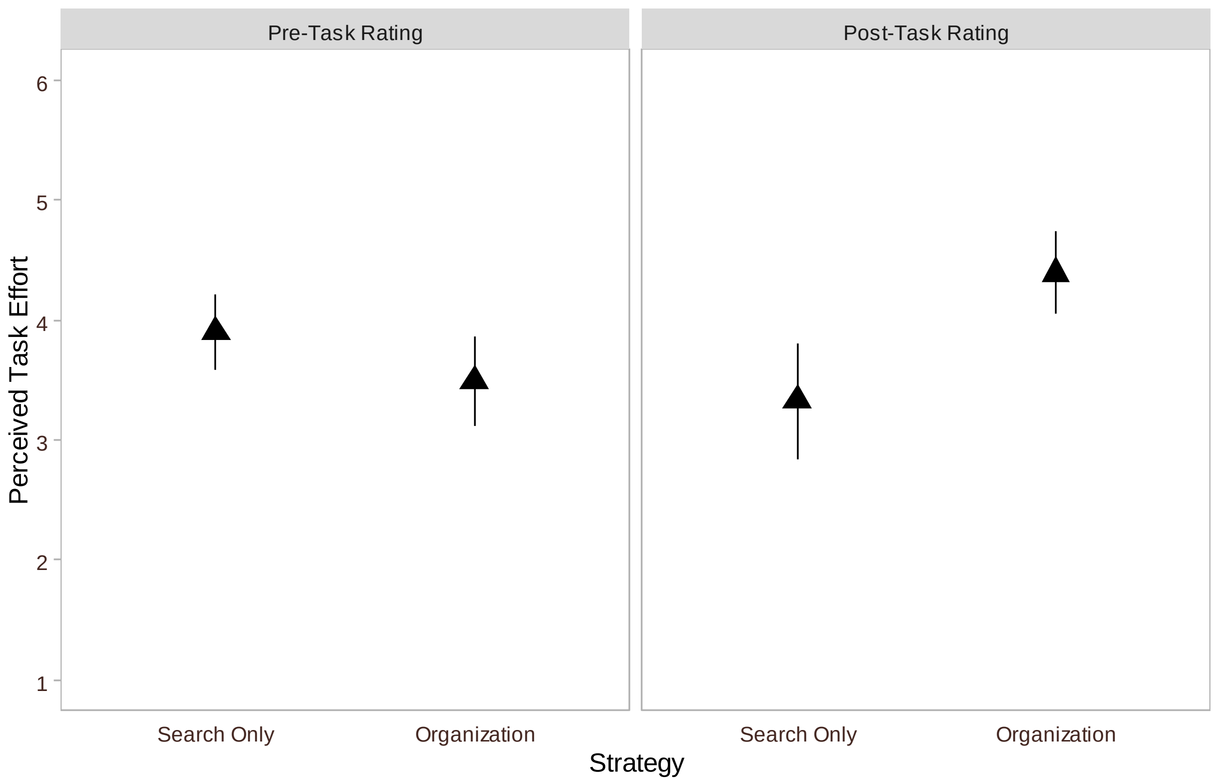


Figure 11. Self-reported task effort ratings on a 6-point Likert scale in Study 4. Error bars represent 95% confidence intervals.

Strategy Selection

Pre-Task Choice. As shown in Figure 5, 73.5% of individuals preferred the search-only strategy prior to the search task, compared to an organization strategy, $\chi^2(1, N = 49) = 10.80$, $p = .001$. Similar to Studies 2 and 3, a relative effort score was calculated by subtracting individuals' effort ratings for the organization strategy from the ratings of the search-only strategy. Again, positive values indicate that individuals perceived the organization strategy as being less effortful. A logistic regression was conducted using the difference score in perceived effort to predict individuals' strategy selection. I found that effort ratings pre-task did not influence which strategy individuals chose, $b = .11$, 95% CI [-.22, .47], $z = .62$, $p = .53$; the intercept in the model remained significant, $b = -1.07$, 95% CI [-1.79, -.44], $z = 3.15$, $p < .001$.

Post-Task Choice. Like in previous studies, most individuals (71.7%) preferred an organization strategy post task, $\chi^2(1, N = 46) = 8.70$, $p < .001$. When relative post-task effort was used as a predictor of strategy selection, I found that relative task effort trended in the opposite direction as expected, though it did not reach statistical significance, $b = -.31$, 95% CI [-.73, .06], $z = 1.60$, $p = .11$. Specifically, this trend showed that as perceived effort for a given strategy increased, individuals were more likely to choose that strategy. When relative task effort was held at 0, the intercept in the model was marginally significantly different from chance, $b = .66$, 95% CI [-.04, 1.40], $z = 1.82$, $p = .07$, indicating that individuals may have a slight preference for the organization strategy when statistically controlling for perceived task effort. Table 7 provides a summary of both pre- and post-task logistic regression models.

Table 7.

Logistic regression model using relative task effort to predict individuals' strategy selection both pre- and post-task completion in Study 4.

	Pre-Task			Post-Task		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	-1.07	-1.79 – -0.44	**<0.001**	0.66	-0.04 – 1.40	0.07
Relative Effort	0.11	-0.22 – 0.47	0.53	-0.31	-0.73 – 0.06	0.11
Observations	49			46		
R^2 Tjur	0.009			0.053		

Perceived Progress

For Study 4, self-reported task progress was derived by measuring the distance between the left end of the progress bar to the center of the vertical line where individuals indicated how much progress they perceived to have made, and dividing that against the total length of the progress bar, resulting in a proportion score. A linear mixed-effects model was constructed that used maximum likelihood estimation. Assigned strategy, (search-only vs organization), the first and second-order polynomial term of proportion time on task (mean-centered), as well as the interaction term between the second-order polynomial and assigned strategy, were included as predictors, and individuals' self-reported proportion progress was used as the criterion variable. I report sum contrasts for categorical predictors, such that the intercept represent the grand mean. After model comparison, I chose a model where the second-order polynomial predictor of proportion time was allowed to vary per individual, as it performed better than a model where only an intercept was allowed to vary, $\chi^2(2) = 43.92$, $p < 0.001$. The data are visualized in Figure 12. Assigned strategy was not a significant predictor of proportion of progress reported, $b = .002$, 95% CI [-.05, .05], $t = .06$, $p = .95$. The second-order polynomial term of proportion time on task was a significant predictor, *b* = .45, 95% CI [.23, .67], *t* = 4.01, *p* < .001, but this relation was not significantly moderated by assigned condition, *b* = .03, 95% CI [-.19, .25], *t* = .27, *p* = .79.

As with Study 3, I also constructed models with only linear terms, as well as their interaction. After comparison, I chose a model wherein the slope of proportion time spent on task was allowed to vary per individual, as it had a significantly better model fit, $\chi^2(2) = 9.75$, *p* = .007. I found that there was a positive linear relation between proportion time spent on task and reported task progress, *b* = .87, 95% CI [.82, .91], *t* = 36.51, *p* < .001. Assigned strategy was not a significant predictor, *b* = .01, 95% CI [-.03, .04], *t* = .34, *p* = .73, nor was it moderated by time spent on task, *b* = .03, 95% CI [-.02, .08], *t* = 1.32, *p* = .19.

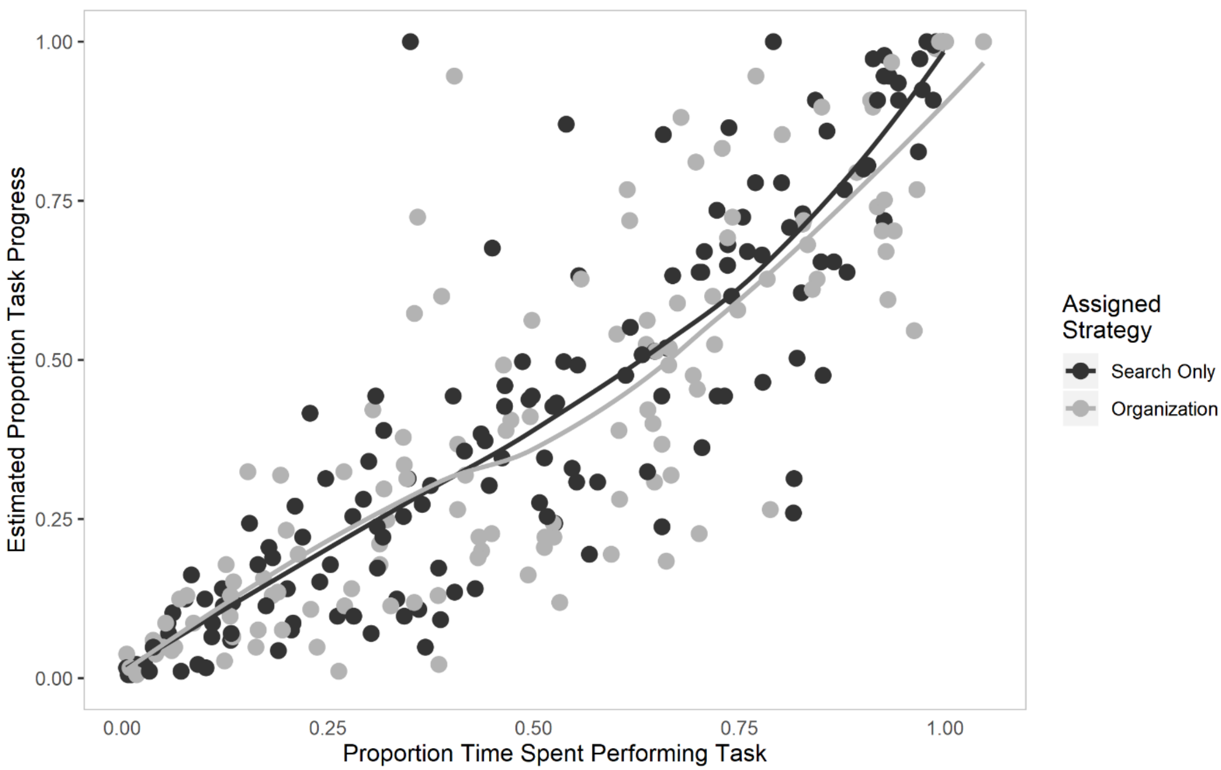


Figure 12. Perceived proportion task progress as a function of the proportion of time spent performing the Lego search task in Study 4. The darker data points represent participants'

responses in the assigned search-only strategy. Solid lines show a best-fitting loess curve for each assigned strategy.

Discussion

The results in Study 4 replicated individuals' strategy selection in Studies 2 and 3 in that individuals initially overwhelmingly preferred a search-only strategy and switched to prefer an organization strategy post-task. However, I did not find strong evidence that these preferences were explained by relative differences in self-reported task effort. In fact, I observed a counterintuitive phenomenon: despite individuals preferring an organization strategy post-task, the reported effort for this strategy was higher than that of the search-only strategy. In addition, I also re-examined individuals' self-reported progress. Unlike in Study 3, where I observed a linear relation between self-reported task progress and time on task, I found that participants' perceived task progress across both assigned strategies followed a non-linear trend such that the rate of perceived task completion accelerated near the end of the task. Though I did not expect to find this pattern, the acceleration in perceived task progress near the end of the task could be attributed to an increasingly visible decrease in the number of Lego pieces in the task space as more target items are found. The fact that I did not find this non-linear pattern in Study 3 may speak to the fact that the two measures of task progress may indeed be tapping into slightly different underlying aspects of task progress. However, it is important to note that I also found strong evidence of a linear pattern across both Study 3 and 4, such that perceived task progress increased the more time individuals spent on the task, suggesting that the perception of task progress is overall relatively linear. Crucially, I found no difference in the form of the relation between perceived and actual task progress across the two different strategies. These results suggest that individuals do not differ in how they perceive task progress across an organization-based vs. search-only search strategy. Thus, the idea that individuals' perception of task progress caused the differences in preference for the two strategies pre-task was not supported.

Combined Analysis

Across three studies, there was a consistent pattern wherein individuals switched their preference post-task from a search-only to an organization strategy. As there were no a priori predictions regarding this observation, I conducted exploratory analyses to examine why this may have been the case. Based on previous work (Hoeffler, Ariely, & West, 2006; Zhu & Risko, 2016), an individual's past experiences and decisions have been reported to influence their future decisions and preferences. As such, I examined whether an individuals' initial strategy selection, as well as their assigned search strategy, influenced their post-task strategy selection.

To do so, a logistic regression was conducted using individuals' pre-task preference and experimenter-assigned search strategy to predict their post-task strategy.[2] Given that fewer individuals chose an organization strategy pre-task, which results in uneven cells across conditions, I combined data across all three experiments in order to maximize power. The means for each condition are depicted in Figure 13, and I report sum contrasts for all categorical variables. Assigned strategy was a significant predictor of post-task preference in that individuals assigned to the organization strategy were more likely to choose an organization strategy post-task, $b = -.48$, 95% CI [-.92, -.06], $z = 2.19$, $p = .03$. Pre-task choice, on the other hand, was only a marginally significant predictor, $b = -.55$, 95% CI [-1.20, .02], $z = 1.88$, $p = .06$. Overall, these results lend support to the idea that an individual's history with that task does influence their

[2] I attempted to construct a model with an interaction term between pre-task preference and assigned strategy, but the interaction term could not be accurately estimated due to the limited number of observations in some of the conditions.

future strategy selection. It is important to note that the intercept in the current model, which represents the grand mean, is also significant, $b = 1.44$, 95% CI [.91, 2.10], $z = 4.84$, $p < .001$, suggesting that the systematic bias towards organization remained even when controlling for prior preference and task history.

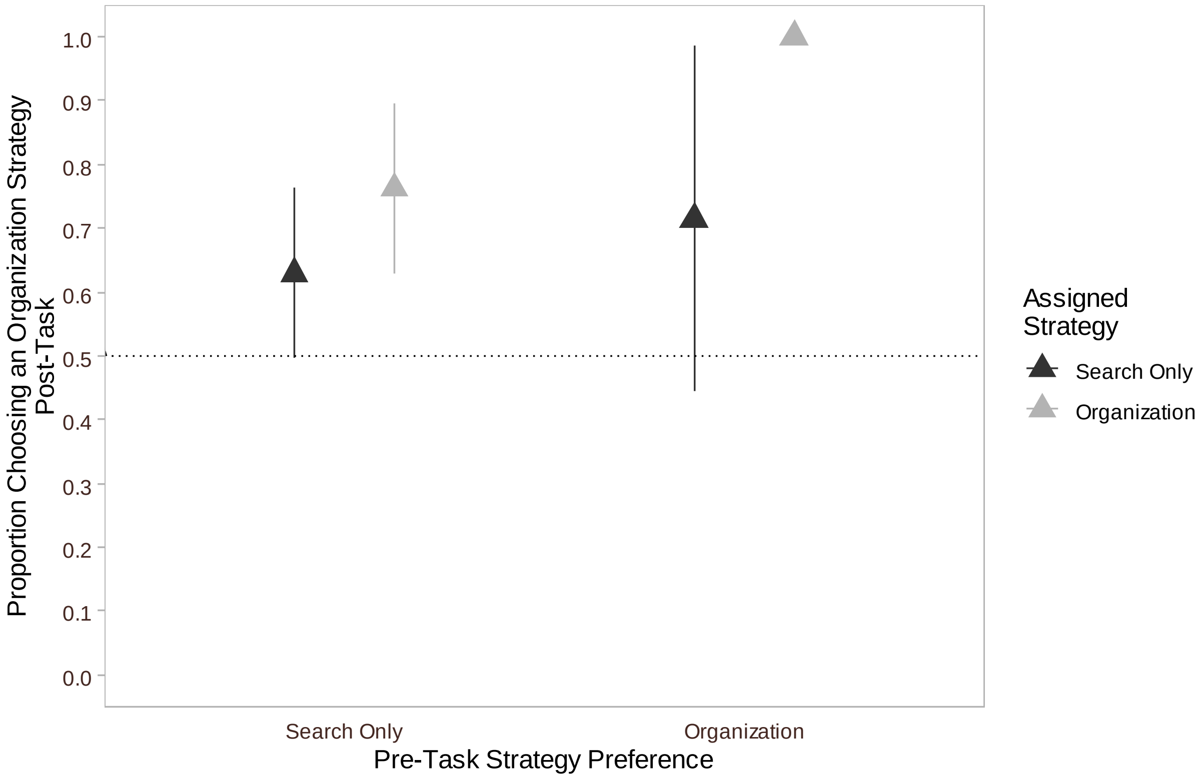


Figure 13. Mean proportion of individuals who preferred an organization strategy post-task as a function of pre-task strategy selection and assigned search task across all experiments. Error bars represent 95% confidence intervals. Note that all individuals who both chose an organization-based strategy initially and were assigned to this same strategy ($N = 19$) picked an organization strategy post-task.

General Discussion

I set out to examine the degree to which individuals preferred to engage in spatial organization before performing a primary task and tested a number of potential factors that may influence their decisions to do so. Overall, there was a consistent pattern in that the majority of individuals avoided choosing an organization strategy when asked to select between an organization- or non-organization-based strategy prior to engaging in a search task. Also consistent was the fact that there was a reversal in strategy selection post-task such that most individuals tended to select an organization-based strategy. These results suggest that individuals had fairly systematic preferences prior to and after completing the search task. When I examined potential factors that could affect individuals' preferences—namely, perceived time costs in Studies 2 and 3, and task effort in Study 4—I found that the former was able to partially explain individuals' preferred search strategies while there was little evidence to indicate that the latter did so.

The results presented in these studies provided consistent and strong evidence that time-based performance considerations played an important role when individuals decided whether to incorporate spatial organization as part of their search strategy. Previous studies have found that individuals will opt to minimize task time even when doing so only led to a small amount of time saved (Gray & Boehm-Davis, 2000; Gray et al., 2006). As such, it is not surprising that individuals would choose a search strategy that is perceived to take less time. However, the overall pattern of results also illustrate that perceived time costs could not wholly account for individuals' strategy selection, since individuals at the aggregate level still preferred one strategy or another when relative task time was statistically controlled at 0. On the other hand, individuals' perceived task effort did not appear to contribute to their strategy selection. This may suggest that any costs or benefits associated with perceived effort in the context of the current experiments may be negligible. These results lend further support to previous research showing that perceived time costs associated with a task may be distinct from perceived task effort (e.g., Dunn & Risko, 2019), as shown by their differentiating ability to statistically predict individuals' strategy selection.

Though the current experiments cannot offer definitive explanations for why individuals showed systematic pre-task strategy selection, Studies 3 and 4 revealed that perceived task progress likely does not underlie the observed bias. As mentioned previously, when individuals engage in spatial organization, they would—at least in one meaningful sense—not be making any progress on the primary task; on the other hand, individuals who engage in a search-only strategy would progress in the search task in a relatively more linear manner. However, individuals do not appear to perceive task progress differently as a function of task strategy. The fact that task progress is perceived relatively linearly as a function of time on task suggests that individuals may perceive organization as more than just an auxiliary action that helps to support a given primary task (e.g., search). In fact, rather than feeling a stall in task progress during an initial organization phase that later accelerates during search, individuals who were assigned to use an organization-based strategy perceived that task progress was made at the same rate regardless of whether they were engaging in the organization or search phase of the task. As such, the current results suggest that individuals perceive that engaging in spatial organization is still propelling them closer to the end goal—despite a lack of *visible* search progress in the number of target pieces found.

The shift in individuals' strategy selection before and after completing the search task on the other hand could, to a degree, be explained by individuals' overall experience with the task.

Specifically, individuals were more likely to choose a strategy that they were previously assigned to use to complete the search task and, to a lesser extent, their initial stated preferences prior to completing the task. These results align with past findings that indicate that an individual's history with a task can significantly influence their future spatial decisions (Zhu & Risko, 2016). Intriguingly, as shown in Figure 13, regardless of one's past strategy selection or assigned strategies, individuals were still more likely to prefer an organization-based strategy post-task. This suggests that having *any* experience with the task—regardless of one's initial preference or assigned strategy—may shift individuals' preferences from one that involves no organization to an organization-based strategy. However, it is also possible that individuals' intention to engage in spatial organization post-task would not translate into future action, as I did not ask participants to perform the search task again. Thus, their stated desire to first organize a space prior to search is under different conditions than their initial (pre-task) preference (i.e., when they knew they would have to actually perform the task). As there is extensive research on the misalignment between individuals' intentions and actual behaviour (Auger & Devinney, 2007; Norberg, Horne, & Horne, 2007; Polites, Karahanna, & Seligman, 2018), more work would be required to assess the degree to which the preferences reported post-task reflect individuals' strategy selection if they knew they would have to perform the task again.

In summary, the current experiments present preliminary evidence that individuals consider the *perceived* performance benefit associated with a given strategy when deciding whether to adopt spatial organization when performing an everyday search task. While organizing one's space has been demonstrated to help reduce the amount of physical and cognitive demands associated with subsequent task performance (Berry et al., 2019; Kirsh, 1995; Solman & Kingstone, 2017a; Zhu & Risko, 2016), these results show that individuals also weigh the perceived performance benefit of doing so. In addition, I also show that an individual's preference to engaging in spatial organization may also depend on their past experience and history with a given task. As such, the studies presented in the current chapter shed light on a more nuanced perspective of whether—and the degree to which—individuals may choose to engage in spatial organization, and provided an important first step for understanding the kinds of factors that may contribute towards such decisions.

Chapter 4

As described in the previous chapter, individuals may choose to engage in spatial organization when doing so is thought to relay a perceived performance benefit. Across Studies 2 to 4, individuals overwhelmingly tended to select a search-only strategy rather than an organization-based one prior to engaging in the search task. This tendency, however, reversed post-task when participants were asked to choose a strategy for similar types of tasks in the future such that individuals were far more likely to select an organization-based strategy. Importantly, individuals' strategy selection—both pre- and post-task—were partially explained by relative task time in that individuals preferred whichever search strategy was expected to take less time to complete the task. Perceived task effort, on the other hand, did not seem to predict individuals' strategy preferences. These results highlight two aspects of individuals' tendency to decide on whether to engage in spatial organization. Firstly, there appears to be a relatively consistent tendency for individuals to select a search-only strategy. Secondly, given that estimated task time predicted strategy selection while task effort did not, it appears that individuals may place greater considerations or importance on some aspects of task performance compared to others.

The aim of the current chapter is to replicate the above-mentioned findings in two online samples—a Amazon Mechanical Turk sample in Study 5 and an undergraduate sample in Study 6. Across two sets of experiments, individuals were asked to complete a hypothetical version of the task described in Chapter 2. Specifically, participants were provided with the same scenario wherein they would imagine having to find target pieces among a pile of Lego building blocks. They were given the choice to complete this task using a search-only (i.e., searching for items without engaging in any spatial organization) or organization-based search strategy (i.e., organizing the pile of Lego prior to engaging in the search task). While I asked participants to estimate task time (Studies 2 and 3) and task effort (Study 4) separately in Chapter 2, the same participants were asked to provide both task time and effort in the current studies. In addition to task time and effort, I also examined whether task enjoyability would affect individuals' strategy selection, as task enjoyability has been documented to be a salient intrinsic motivator in a number of contexts (Kaufmann, Schulze, & Veit, 2011; Waterman, 2005).

Study 5a & 5b

In Study 5a and 5b, I examined the tendency for individuals to select an organization-based vs. search-only search strategy in two general samples of individuals obtained using Amazon Mechanical Turk. There were minor differences in the order in which search strategy choices were presented to participants across the two samples; in Study 5a, the organization-based strategy was consistently presented as the first option when individuals were asked to choose between the two strategies, and was the first strategy that individuals had to provide estimates for when asked to estimate task time, effort, and enjoyability. For Study 5b, the search-only strategy was consistently presented first. The procedure across both studies were otherwise identical.

Method

Participants

I recruited a total of 80 individuals (with 40 participants in each sample) living in the United States through Amazon Mechanical Turk and gave $1 USD in remuneration for their participation. Of the 80 participants, 51 self-identified as male (E5a = 25; E5b = 26), 28 as female (E5a = 15; E5b = 14), and 1 as transgender (from E5b). The mean age of the total sample was 33.94 years (SD = 8.85; M_{E5a} = 34, SD_{E5a} = 8.29; M_{E5b} = 33.88, SD_{E5b} = 9.49). All participants in the reported studies provided informed consent before participating in the study. Upon completing the study, they were directed to a page with debriefing information regarding the purpose of the study. Ethical approval for the study was obtained from the Research Ethics Board at the University of Waterloo.

Materials & Procedure

Upon agreeing to participate in the study, participants first provided their demographic information (i.e., gender and age). They were then given instructions to complete the task: "You will be using the following scenario to answer the questions. In a search task involving Lego, the objective is to look for specific Lego pieces among a pile of random pieces as shown in picture A. The pieces you are looking for will be used to build all 3 structures shown in picture B." The picture stimuli participants were shown in the task are depicted exactly as shown in Figure 3 in Chapter 2.

On the next page, participants were told that they could use one of two strategies to complete the search task and were asked to choose their preferred strategy. The instruction was as follows: "When it comes to working with Lego, one strategy is to first sort the pile of Lego into categories (e.g., by colour or by shape), then search for the pieces. Another strategy is to just search for the pieces without doing any categorization. If you were to do this task, which strategy would you prefer?" Participants were asked to provide the reason why they chose their preferred strategy in an open-response box.

After providing their preferred search strategy, participants were asked to estimate (1) how long the task would take as well as (2) how effortful, and (3) how enjoyable it would be to complete the task using each of the two strategies. All participants were asked to provide these estimates in that order. For estimated task time, participants were given a free response box to type out their response. Task effort and enjoyability were measured using a 6-point Likert scale with the anchors “not at all effortful/enjoyable” and “very effortful/enjoyable” at the two ends of the scale. As noted above, the presentation of the strategies was such that the organization-based strategy was always presented first for all questions asked in Study 5a; for Study 5b, the search-only based strategy was always presented first. Once participants completed all components of the study, they were directed to the debriefing page.

Results

All analyses were conducted using *R* (R Core Team, 2019). I report 95% profile likelihood based confidence interval for estimates reported in logistic regression models (Meeker & Escobar, 1995) as extracted using the *sjPlot* package (Lüdecke, 2018). Correlation tables were calculated and formatted via the *apaTables* package (Stanley, 2018). As the pattern of results were similar across Studies 5a and 5b, I combined the two samples and report an analysis for the overall sample. Given that reported estimates for time, effort, and enjoyability are not normally distributed, I employed the Wilcoxon signed-rank test when reporting differences between individuals’ raw estimates and report medians for each condition as opposed to means.

Note that no participant was excluded in these samples, as none of the participants provided unusual responses when they were asked to elaborate on their strategy selection in an open-ended response. A response was classified as an unusual response if (1) participants did not provide any reason at all or (2) the response bore no relation to the question that participants were asked to answer (e.g., “good”).

Task Estimates

Estimated Task Time. Given the significant positive skew in estimated task time, I compared individuals’ estimated task time for each strategy using the Wilcoxon signed-rank test.

Median ranked estimates provided for the organization-based strategy (15 minutes) were significantly lower than the search-only strategy (23.5 minutes; $V = 505.5$, $p < .001$). Of the 80 total participants, 55 estimated that the organization-based strategy would take less time than the search-only strategy, 20 individuals reported the opposite, and 5 estimated that the two strategies would take the same amount of time to complete the task.

Estimated Task Effort. A Wilcoxon signed-rank test revealed that individuals' estimates for the organization-based strategy was marginally less effortful (Median = 4) compared to the search-only strategy (Median = 5; $V = 1058$, $p = .05$).[3] The majority of participants ($N = 46$) expected the organization-based strategy to require less effort compared to a search-only strategy; 29 participants reported the opposite, and 5 estimated that the two strategies required the same amount of effort.

Estimated Task Enjoyability. Finally, a Wilcoxon signed-rank test revealed that organization-based strategy was rated to be more enjoyable (Median = 4) relative to a search-only strategy (Median = 3; $V = 1945.5$, $p < .001$). Of the total participants, 53 rated the organization-based strategy as more enjoyable relative to a search-only strategy; 17 participants reported the opposite, and 10 rated the two strategies as being equally enjoyable.

Strategy Preference

First, I assessed whether individuals had a strong preference for one strategy over another in the current sample. I found that 75% of the participants preferred the organization-based over the search-only strategy, $\chi^2(1, N = 80) = 20$, p < .001.

To examine whether individuals' preferred strategies were related to perceived task time, effort, and enjoyability, I computed a difference score for each participant by subtracting the

[3] For Study 5a, there was not a significant difference between the ratings between the two strategies ($p = .37$), whereas for Study 5b, the difference was marginally significant ($p = .054$).

estimates provided for the organization-based strategy from the search-only strategy (i.e., search estimate minus organization estimate). For relative task time, a positive difference score would mean that the organization-based strategy is estimated to take less time to complete the task. Similarly, a positive difference score for relative task effort would indicate that the organization-based strategy was perceived to be less effortful. In contrast, a positive difference score for relative task enjoyability would indicate that the search-only strategy was perceived to be more enjoyable compared to the organization-based strategy.

I conducted logistic regressions individually for each difference score predicting individuals' preference for an organization-based (coded as 1) or search-only strategy (coded as 0). This served as a direct comparison with results in Chapter 2, as participants provided task time and task effort in separate studies. Due to quasi-separation in the regression model wherein relative task time was included as the predictor, data were removed from 2 participants whose relative task time difference score were greater than 70. In order to better compare results across the other predictors, data from those participants were also removed for logistic regression models involving relative task effort and enjoyability (i.e., performing a listwise deletion across all 3 variables). As such, the following reported analyses contain data from the remaining 78 participants.

Relative Task Time. I found that relative task time positively predicted strategy preference, $b = .25$, 95% CI [.14, .40], $z = 3.82$, $p < .001$. In other words, individuals preferred whichever strategy was thought to take the least amount of time to complete the search task. In addition, when relative task time was statistically held at 0, individuals do not appear to show a strong preference towards one strategy or another as indicated by the non-significant intercept in the model, $b = .47$, 95% CI [-.25, 1.21], $z = 1.28$, $p = .20$.

Relative Task Effort. Relative task effort, by itself, was also a significant predictor of strategy preference, $b = .68$, 95% CI [.37, 1.05], $z = 3.95$, $p < .001$. That is, individuals preferred the less effortful of the two strategies. In this model, the intercept remained significant, $b = 1.20$, 95% CI [-.60, 1.89], $z = 3.68$, $p < .001$. This means that even accounting for relative task effort, individuals' overall preference for an organization-based strategy could not be sufficiently explained.

Relative Task Enjoyability. Relative task enjoyability negatively predicted strategy preference, $b = -1.10$, 95% CI [-1.68, -.66], $z = 4.29$, $p < .001$, such that individuals preferred the strategy that was perceived to be more enjoyable. When relative task enjoyability was statistically held at 0, individuals showed a marginally significant preference for the organization-based strategy, $b = .64$, 95% CI [-.07, 1.38], $z = 1.76$, $p = .08$.

Table 8.

Means, standard deviations, and correlations with confidence intervals. Relative difference scores are calculated by subtracting the estimates provided for the organization-based strategy from the search-only strategy (i.e., search estimate minus organization estimate).

Variable	*M*	*SD*	Relative Task Time	Relative Task Effort
Relative Task Time (min)	11.8	22.3		
Relative Task Effort	0.44	2.09	.33** [.12, .51]	
Relative Task Enjoyability	-1.12	2.2	-.39** [-.56, -.19]	-.42** [-.59, -.22]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$.

Multiple Logistic Regression Model. As shown in Table 8, there was a moderate degree of correlation between participants' estimates. As such, an additional logistic regression was constructed with all 3 difference score predictors to assess the degree to which they uniquely predicted strategy preference. I found that relative task time remained a significant predictor, $b = .15$, 95% CI [.04, .31], $z = 2.29$, $p = .02$. Relative task enjoyability was also a significant predictor, $b = -.95$, 95% CI [-1.78, -.35], $z = 2.70$, $p = .01$. Relative task effort, on the other hand, was not a significant predictor, $b = .47$, 95% CI [-.21, 1.17], $z = 1.37$, $p = .17$. The model also did not have a significant intercept, $b = .44$, 95% CI [-.54, 1.47], $z = .88$, $p = .38$, meaning that when relative task time, effort, and enjoyability between the two strategies were all statistically controlled at 0, individuals do not show a strong preference for either strategy. The results of both the single- and multiple-predictor models are summarized in Table 9.

Table 9.

Logistic regression model using relative task time, effort, and enjoyability to predict individuals' strategy selection in Study 5.

	Perceived Time Only			**Perceived Effort Only**			**Perceived Enjoyability Only**			**Multiple Predictors**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	0.47	-0.25 – 1.21	0.20	1.20	0.60 – 1.89	**<0.001**	0.64	-0.07 – 1.38	0.08	0.44	-0.54 – 1.47	0.38
Relative Time	0.25	0.14 – 0.40	**<0.001**							0.15	0.04 – 0.31	**0.02**
Relative Effort				0.68	0.37 – 1.05	**<0.001**				0.47	-0.21 – 1.17	0.17
Relative Enjoyability							-1.10	-1.68 – -0.66	**<0.001**	-0.95	-1.78 – -0.35	**0.01**
Observations	78			78			78			78		
R^2 Tjur	0.540			0.291			0.496			0.704		

Discussion

To summarize, individuals in the current study had a preference towards an organization-based strategy. As with previous in-lab participants, there was also evidence that individuals in the current study considered the perceived performance benefits associated with each strategy when making strategy selections. When relative task time, effort, and enjoyability were included as separate predictors, they were each significant predictors of individuals' strategy preference. Further, when all 3 factors were included in a single logistic regression, relative task time and enjoyability remained significant, whereas relative task effort did not.

There were a number of differences between the current experiment and previous in-lab results as reported in Chapter 2. Firstly, whereas individuals in Chapter 2 held a strong preference against adopting an organization-based search strategy in a laboratory environment, participants in the current sample favored an organization-based strategy. Secondly, though relative task time was a significant predictor in both the current study and previous in-lab studies, the degree to which this predictor was able to account for individuals' strategy selection at the aggregate level varied. Specifically, in Chapter 2 (Studies 2 and 3), the inclusion of relative task time alone could not sufficiently explain individuals' preference against choosing an organization-based strategy (i.e., the model had a significant negative intercept). In the current study, however, including relative task time in a logistic regression model was able to sufficiently explain the observed overall preference towards organization. Thirdly, relative task effort was not a significant predictor with in-lab participants but was a significant predictor in the current study when it was the sole predictor in a logistic regression model. One potential explanation for these discrepancies is that participants in Chapter 2 were obtained from a university undergraduate population, whereas participants in Study 5 were sampled from a more general population. As such, Study 6 was carried out in order to examine whether the observed differences across these two sets of studies were due to differences in samples.

Study 6a & 6b

The primary purpose of Study 6 was to serve as a replication of Study 5 while sampling participants from the same population as previous in-lab studies as described in Chapter 2. If results from Study 6 closely align with results from previous in-lab studies, this would serve as evidence consistent with the idea that there are differences in response across samples. On the other hand, if these results more closely align with those presented in Study 5, then it is possible that the mode through which the study is administered (e.g., online vs. in-lab) may have affected individuals' responses. Except for minor differences across Studies 6a and 6b, the procedure was otherwise identical.

Method

Participants

Eighty-two students from the University of Waterloo completed the study online for course credits (I obtained data from 42 and 40 participants respectively for E6a and E6b). Of the total sample, 67 identified as female (E6a = 38; E6b = 29) and 15 as male (E6a = 4; E6b = 11). The mean age of the participants was 20.85 years (SD = 4.28; M_{E6a} = 20.31, SD_{E6a} = 2.71; M_{E6b} = 21.43, SD_{E6b} = 5.45). Informed consent was obtained from individuals before taking part in the study, and all participants received debriefing information upon completing the study. Ethical approval for the study was obtained from the Research Ethics Board at the University of Waterloo.

Procedure

The experimental procedure was nearly identical to the instructions presented in Study 5a such that the organization-based strategy was always presented as the first choice for all participants. In Study 6a, participants were instructed to estimate how long it would take for them to complete the task using either strategy. In Study 6b, this statement was qualified by asking participants to provide time estimates in minutes.

Results

As with Study 5, I report analyses combined across Studies 6a and 6b and note any differences across samples. Prior to analysis, I removed data from 4 participants who did not provide numerical values for estimated task completion times. Unless otherwise indicated, the following analyses were conducted on data from the remaining 78 participants. Note that none of the participants were excluded due to data quality reason (i.e., having provided an unusual open-ended response when asked to elaborate on their reason for making their strategy selection).

Task Estimates

Estimated Task Time. A Wilcoxon signed-rank test revealed that the median ranked estimates provided for the organization-based strategy (20 minutes) did not significantly differ from estimates provided for the search-only strategy (25 minutes; $V = 1046$, $p = 0.13$). Across 78 participants, 39 estimated that the organization-based strategy would take less time than the search-only strategy, 33 individuals reported the opposite, and 6 estimated that the two strategies would take the same amount of time to complete the task.

Estimated Task Effort. A Wilcoxon signed-rank test revealed that individuals estimated the organization-based strategy to be just as effortful (Median = 4) as the search-only strategy (Median = 4; $V = 1212$, $p = 0.70$). There were 36 participants who estimated that the organization-based strategy to require less effort compared to the search-only strategy; 35

participants reported the opposite, and 7 reported that the two strategies would require the same amount of effort.

Estimated Task Enjoyability. Similar to task effort, an organization-based strategy was rated to be equally enjoyable (Median = 4) as a search-only strategy (Median = 4; $V = 1211$, $p = 0.10$). Of all participants, 40 rated the organization-based strategy as more enjoyable relative to the search-only strategy; 22 participants reported the opposite, and 16 rated the two strategies as being equally enjoyable.

Strategy Preference

With 51.3% of participants preferring an organization-based strategy, individuals in the current study did not appear to have a strong preference for either strategy in the current sample, $\chi^2(1, N = 78) = .05$, $p = .82$. Next, I assessed whether strategy preference was separately predicted by relative task time, effort, and enjoyability. For similar reasons as in Study 5, I performed listwise deletion on data from 3 additional individuals who had a relative task time estimate of greater than 70. As such, the following logistic regressions were conducted on data from the remaining 75 participants.

Relative Task Time. Participants were more likely to choose whichever strategy that was thought to minimize task time, $b = .09$, 95% CI [.04, .14], $z = 3.52$, $p < .001$. The intercept in this model was not significant, $b = -.19$, 95% CI [-.72, .33], $z = .70$, $p = .49$.

Relative Task Effort. When relative task time was included as the sole predictor of strategy selection, participants were more likely to pick the strategy that was perceived to be less effortful, $b = .32$, 95% CI [.09, .57], $z = 2.66$, $p = .01$. The intercept was not significant, $b = -.09$, 95% CI [-.58, .39], $z = .37$, $p = .71$.

Relative Task Enjoyability. As relative enjoyability across strategies increased, participants were increasingly likely to select the more enjoyable strategy, b = -1.04, 95% CI [-1.62, -.62], z = 4.13, p < .001. Again, the intercept in this model was not significant, b = -.53, 95% CI [-1.24, .10], z = 1.57, p = .12.

Table 10.

Means, standard deviations, and correlations with confidence intervals. Relative difference scores are calculated by subtracting the estimates provided for the organization-based strategy from the search-only strategy (i.e., search estimate minus organization estimate).

Variable	*M*	*SD*	Relative Task Time	Relative Task Effort
Relative Task Time (min)	8.52	35.8		
Relative Task Effort	0.1	2.22	-0.03 [-.25, .19]	
Relative Task Enjoyability	-0.45	2.36	-.30** [-.49, -.08]	-0.07 [-.29, .15]

Note. *M* and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates p < .05. ** indicates p < .01.

Multiple Logistic Regression Model. Finally, I assessed the degree to which these factors uniquely predicted strategy preference. Table 10 shows the correlation across the 3 predictor variables in Study 6. When holding all other factors constant, relative task time was only a marginal predictor, b = .05, 95% CI [.00, .10], z = 1.81, p = .07. On the other hand, relative task effort remained a significant predictor, $b = .47$, 95% CI [.10, .92], $z = 2.31$, $p = .02$, as did relative task enjoyability, $b = -1.07$, 95% CI [-1.72, -.59], $z = 3.78$, $p < .001$. The intercept in this model was not significant, $b = -.57$, 95% CI [-1.39, .14], $z = 1.50$, $p = .13$. Table 11 provides a summary of the models with both single- and multiple-predictors.

Discussion

In Study 6, I again observed that relative task time, effort, and enjoyability each predicted which strategy participants preferred when included as separate predictors. When all three factors were included in a single model, both relative task effort and enjoyability remained significant predictors, while relative task time becomes a marginally significant predictor. However, unlike in Study 5 and previous in-lab studies, participants no longer showed a strong preference towards either an organization-based strategy or a search-only strategy. I will address this issue in more detail in the General Discussion.

Table 11.

Logistic regression model using relative task time, effort, and enjoyability to predict individuals' strategy selection in Study 6.

	Perceived Time Only			**Perceived Effort Only**			**Perceived Enjoyability Only**			**Multiple Predictors**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	0.47	-0.25 – 1.21	0.20	1.20	0.60 – 1.89	**<0.001**	0.64	-0.07 – 1.38	0.08	0.44	-0.54 – 1.47	0.38
Relative Time	0.25	0.14 – 0.40	**<0.001**							0.15	0.04 – 0.31	**0.02**
Relative Effort				0.68	0.37 – 1.05	**<0.001**				0.47	-0.21 – 1.17	0.17
Relative Enjoyability							-1.10	-1.68 – -0.66	**<0.001**	-0.95	-1.78 – -0.35	**0.01**
Observations	78			78			78			78		
R^2 Tjur	0.540			0.291			0.496			0.704		

General Discussion

In the current chapter, I aimed to replicate the main finding from Chapter 2 wherein individuals selected against using an organization-based strategy and selected strategies that generally tended to minimize perceived task time. I also aimed to examine the extent to which individuals considered other factors such as enjoyability. Across two different online samples, I found consistent evidence that individuals generally tend to prefer whichever strategy was perceived to take less time, less effort, and was more enjoyable to use when each factor was the sole predictor in a model. That is, all 3 factors seem to have some degree of influence over individuals' strategy preference. When all three predictors were included in a multiple logistic regression to account for correlation among the three predictors, the unique and significant contribution from each predictor was most consistent for enjoyability, then task time, and less consistent for perceived task effort. Taken together, these results indicate that although individuals seem to weigh time, effort, and enjoyability when determining their preferred strategy, some factors may have a greater influence on individuals' strategy preference (and more consistent across studies) than others.

The link between perceived task time and strategy preference was consistent when it was the sole predictor in a logistic regression; this is true for both the current studies and previous in-lab studies described in Chapter 2. Even when holding the other two predictors constant, relative task time remained a relatively consistent predictor across Studies 2 and 3. In other words, even when controlling for other factors, perceived difference in task time was able to uniquely predict individuals' strategy preference. These results further lend support to the idea that individuals prefer to minimize task time when possible. In contrast, task effort was not a consistent predictor of strategy preference. In Chapter 2, perceived task effort was not a significant predictor of strategy preference. However, task effort—when included as the only predictor in Studies 5 and 6—significantly predicted strategy preference. Moreover, there are still differences between the two online samples. Notably, task effort was moderately correlated with both task time and enjoyability in Study 5, but these correlations were not observed in Study 6. As a result, when all 3 predictors were entered into the same model, perceived task effort only remained a significant predictor in Study 6. Given the lack of consistent pattern across the in-lab studies and the two online studies, it is difficult to draw firm conclusions about the role of perceived task effort in individuals' search strategy selection. Finally, perceived task enjoyability was included as a novel factor in Studies 5 and 6. It was a significant and consistent predictor regardless of whether task time and effort were considered in the same model. This is consistent with the idea that enjoyability can be a strong intrinsic motivator (e.g., Waterman, 2005). That is, individuals are more likely to perform a given tasks when they perceive it to be more enjoyable.

Interestingly, I did not observe consistent preferences in individuals' strategy; whereas participants from a Amazon Mechanical Turk sample tended to select an organization-based strategy over a search-only strategy, I found that our online student sample did not show a preference for either strategy. These results also stand in contrast with previous in-lab studies wherein individuals showed a strong preference against incorporating organization as part of their search strategy. Moreover, in in-lab studies, relative task time was not able to sufficiently account for individuals' strategy preferences, resulting in a significant model intercept that indicated an unexplained bias towards the search-only strategy. On the other hand, individuals' strategy selection could be entirely accounted for by relative task time in both online samples. That is, although individuals were more likely to select an organization-based strategy, this tendency was driven by the perception that organization would lead to faster task completion.

One factor that may explain differences between individuals' overall strategy selection in the current samples and the laboratory samples in Chapter 2 is that participants were expected to complete the search task in the lab-based studies but were not expected to do so when presented with the scenario in an online study. It is possible that individuals may exhibit a kind of present bias—that is, a tendency to focus on the more immediate costs or gains of one's action compared to future ones—when performing a real-world version of the task as opposed to a hypothetical one (O'Donoghue & Rabin, 1999). Since participants are told that one needs to organize all of the Lego pieces first before engaging in search in an organization-based strategy, this means that individuals must first construct an organized space, incurring an immediate cost up front before reaping the benefits of organization. At this point, individuals would gauge the *perceived* effort and time required to complete this portion of the task and decide if incurring these costs upfront would outweigh the benefits of searching within this environment. If the present bias was at play, then the immediate perceived costs associated with organization may loom larger or appear to be more salient to individuals when they are expected to complete a physical search task than the perceived costs of simply searching for the target pieces without any organization. On the other hand, the immediate costs associated with organization may not be as salient in a hypothetical scenario since individuals are aware that they do not need to perform the actual search task.

Despite a number of idiosyncrasies among in-lab and online samples, individuals nonetheless showed a strong tendency to weigh the relative costs in each strategy when determining the kinds of strategies that they would prefer to employ in a search scenario—though the strength of the influence may vary depending on the factors in question. In particular, across both lab- and online-based studies, task time appears to be an important and consistent consideration that individuals use to determine whether to engage in spatial organization.

However, it is important to keep in mind that while there appears to be clear relation between relative task time and strategy preference, further work is required to establish the causal link between these two factors.

Chapter 5

In previous chapters, I demonstrated that individuals' selected search strategies depended on a number of factors. In particular, strategy selection depended on the perceived relative time costs associated with each strategy both in a real-world search task (Chapter 2) and hypothetical scenarios (Chapter 3). As the task time benefit associated with an organization-based strategy increased, participants were increasingly more likely to select that strategy over a search-only task strategy, and vice versa. However, until now, I focused on measuring individuals' perceived task time for each strategy, as opposed to manipulating this factor. As such, there is insufficient evidence to suggest that individuals' strategy selection resulted from relative task time differences. For instance, it remains possible that the strategies that individuals select and the perceived task time associated with each of the strategies are a result of pre-existing preferences or habits that individuals carry from their previous experiences.

As such, our goal in the current chapter was two-fold. Firstly, I sought to experimentally establish the causal relation between relative task time and strategy selection by systematically manipulating task time. Secondly, I aimed to examine whether individuals do, in fact, have pre-existing dispositions towards a particular strategy and the degree to which their dispositions might systematically alter their strategy selection under different time costs.

Study 7

In order to examine the causal link between task time and strategy selection, participants were provided with a single hypothetical object search scenario. In the scenario provided, participants could complete the task using one of two available strategies—an organization-based search strategy and a search-only strategy. Importantly, participants were given information about how much time they could expect was needed to complete the task using each strategy. Based on the information provided, participants would then select their preferred task strategy. Importantly, I systematically manipulated two different aspects of task time. First, I included manipulations of relative task time, or the *difference* in time cost between the two strategies. Note that this is analogous to the measure of estimated relative task time obtained in previous studies described in Chapters 2 and 3. If there was a causal relation between task time and individuals' strategy selection, then I would expect to replicate the same pattern of results as depicted in the previous chapters. That is, I would expect individuals to show an increased likelihood to select a particular strategy if that strategy is described as more time efficient.

In addition, I wanted to examine whether *overall task length*—independent of the relative task time between strategies—might also influence individuals' strategy selection. In the context of the current design, an increase in task length would be proportional to the size of the task space, meaning that there would more Lego pieces that one would be required to search through and/or more target pieces that one would need to search for. As the overall task size increases, there may be a greater perceived cognitive benefit in attempting to partition or categorize available items (e.g. Solman & Kingstone, 2017). As such, it is possible that individuals may be more likely to choose an organization-based strategy over a search-only one as the task length increases, independent of the *relative* time difference across the two strategies. In other words, even when both strategies are expected to take the same amount of time (i.e., a relative time difference of 0), individuals may be more inclined to choose an organization-based strategy when the task is expected to take longer to complete overall.

Lastly, I examined individual dispositions towards a given strategy. To do so, participants were asked to provide open-ended responses explaining their reason or motivation behind their strategy selection, which would be later coded and categorized.

Method

Participants

I aimed to recruit 585 individuals living in the United States through Amazon Mechanical Turk. This sample size was determined by having 15 participants for each of the 39 task scenarios in the study. This means that roughly 200 participants would be randomly assigned to each of the 3 levels of absolute task time, a reasonable sample size for detecting a medium-sized effect. The final sample resulted in data from 587 individuals. The mean age of the sample was 34.87 years (*SD* = 10.73), with 265 participants identifying as female and 322 identifying as male. All participants provided informed consent before participating in the study and were given $0.67 USD in remuneration for their participation. Upon completing the study, they were directed to a page with debriefing information regarding the purpose of the study. Ethical approval for the study was obtained from the Research Ethics Board at the University of Waterloo.

Design

Task time was manipulated in a 3 (absolute base time: 15, 30, 60 minutes) by 13 (relative task time: -25, -15, -10, -5, -2, -1, 0, 1, 2, 5, 10, 15, 25) between-subjects design.

Task Procedure & Design

Once participants have given their consent, which provided a general overview of the study, they were directed to provide their demographic information (i.e., gender and age). They were then provided with a single scenario wherein they would be searching for target Lego pieces that would be used to construct specific shapes from a Lego pile. An example of such a scenario was provided and was identical to Figure 3 (see Chapter 2). Participants were told that this task could be completed using one of two strategies: (1) organize all of the pieces into categories (e.g., by colour, shape, etc.) first before searching for the target pieces or (2) directly search for the pieces without performing any organization throughout the task. Importantly, participants are shown how many minutes each task would take if they were to complete this task. I systematically manipulated two aspects of task time. Firstly, task completion time for one of the strategies was fixed to 15, 30, or 60 minutes; I refer to these as the absolute base times. Secondly, I manipulated relative task time by adding 0, 1, 2, 5, 10, 15, or 25 to each set of absolute base time per strategy, resulting in 13 different relative task time scenarios. Based on the information provided, participants would choose their preferred strategy (i.e., organization-based or search-only strategy), and would provide a reason for their choice in the open-ended response box provided. Finally, participants were directed to the debriefing page.

Results

Exclusion Criteria

In order to ensure data quality, participants were excluded based on two criteria. First, in cases where there were duplicate response IDs (N = 3), only the first set of responses from the participant were retained; any subsequent responses from the same ID were removed. Secondly, any participants who provided an unusual response in the open-ended response box were removed (N = 23). A response was classified as an unusual response if (1) participants did not provide any reason at all or (2) the response bore no relation to the question that participants were asked to answer (e.g., “good”).

Analysis

All analyses were conducted using *R* (R Core Team, 2019). I report 95% likelihood ratio confidence intervals for estimates reported in logistic regression models (Meeker & Escobar, 1995) as extracted using the *sjPlot* package (Lüdecke, 2018).

Strategy Selection

Overall, 66.7% of participants selected the organization-based strategy over the search-only strategy, $\chi^2(1, N = 567) = 62$, $p < .001$. Next, I analyzed individuals' strategy selection considering both absolute base time and relative task time. For relative task time, I subtracted the manipulated task time for the organization-based strategy from the search-only strategy. For example, participants given a scenario wherein search would take 20 minutes to complete using the organization strategy and 15 minutes to complete would result in a relative task time of -5 minutes. Absolute base time was mean centered to allow for easier interpretation of model intercepts.

First, I examined a model with absolute base time and relative task time predicting strategy selection. Absolute base time was not a significant predictor, $b = .01$, 95% CI [-.00, .02], $z = 1.29$, $p = .20$. Relative task time, on the other hand, significantly predicted strategy selection, $b = .05$, 95% CI [.04, .07], $z = 6.15$, $p < .001$. In other words, individuals were more likely to select the faster strategy. Finally, the model intercept was positive and significant, $b = .74$, 95% CI [-.56, .93], $z = 7.90$, $p < .001$, indicating that when absolute base time was at the mean and relative task time was at 0, there was a systematic bias for individuals to choose the organization-based strategy. I also tested a second model by including the interaction term between absolute base time and relative task time. The interaction effect was not significant, $b = .001$, 95% CI [-.00, .002], $z = 1.67$, $p = .09$. See Figure 14 for a graphical depiction of the data and Table 12 for a summary of the logistic regression model.

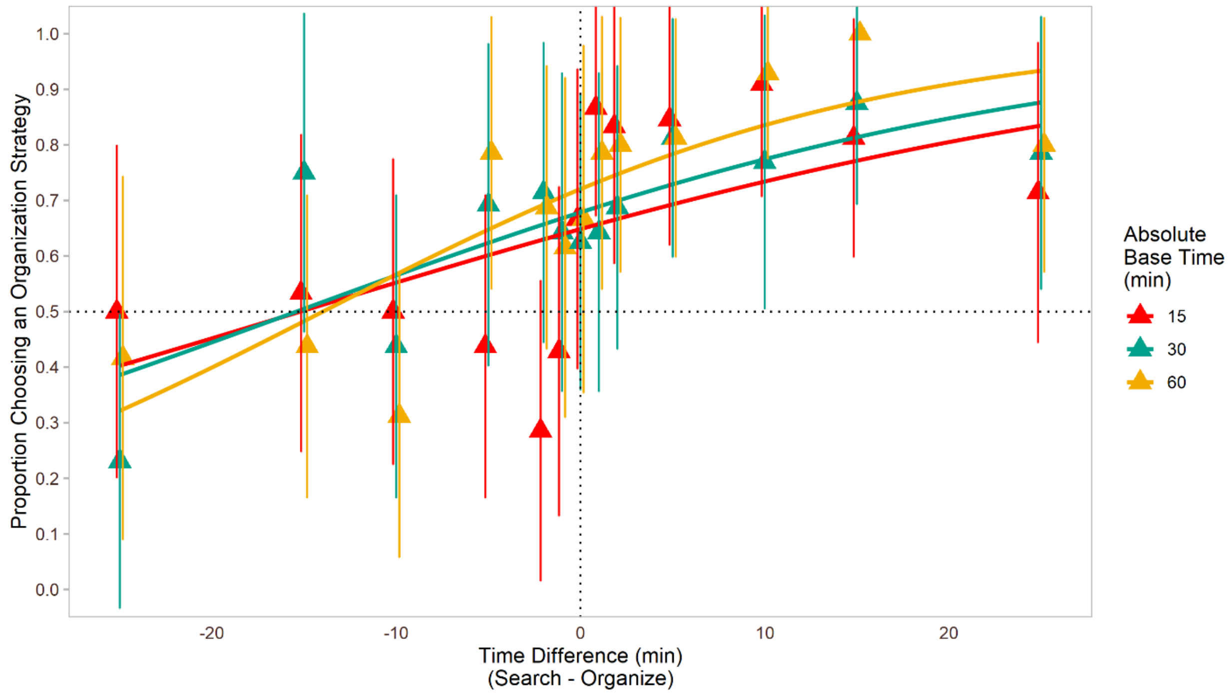


Figure 14. Proportion of individuals choosing organization-based search strategy as a function of relative task time and absolute base time in Study 7. Solid fit lines represent the estimated sigmoidal curve associated with each base time condition. Error bars represent 95% confidence intervals. The horizontal grey dotted line represents chance, and the vertical grey dotted line delineates when the two strategies took the same amount of time.

Table 12.

Logistic regression model using relative task time and absolute base time to predict individuals' strategy selection in Study 7.

	Strategy Selection			
Predictors	*Log-Odds*	*CI*	*Statistic*	*p*
Intercept	0.757	0.572 – 0.947	7.907	**<0.001**
Relative Time	0.053	0.037 – 0.071	6.294	**<0.001**
Absolute Base Time	0.008	-0.002 – 0.018	1.515	0.130
Relative Time * Absolute Base Time	0.001	-0.000 – 0.002	1.493	0.135
Observations	561			
R^2 Tjur	0.085			

Individual Disposition Towards A Given Strategy

A research assistant coded participants' open-ended response to identify their disposition towards a given strategy. Should participants be motivated by more than one preference, the coder was asked to use their judgement to identify the primary motivation for their strategy selection. This approach identified 3 major motivations for individuals' strategy selection: an organization preference, a search-only preference, and a preference to minimize task time. To ensure reliability of coding, a second coder was told to recode participants' open-ended responses into these 3 categories. The inter-rater reliability between the two coders, as measured by Cohen's unweighted Kappa, was .60. In order to use these coded dispositions for analysis, a third coder resolved any conflicts between the coding provided by the first two coders. The percentage of individuals categorized into each of these disposition categories are shown in Table 13. Based on these categorizations, I assessed whether these individual differences in strategy preference may be related to systematic differences in which strategy was selected.

Table 13

Proportion of individuals in each sample categorized as having each type of strategy disposition.

Disposition Categories	Study 7	Study 8		Study 9	
	Researcher Coded	Self-Report	Researcher Coded	Self-Report	Researcher Coded
Time Minimization	35.7%	56.8%	57.4%	62.6%	64.1%
Organization Preference	46.2%	18.2%	25.7%	19.0%	23.1%
Search Preference	15.0%	12.8%	15.5%	7.2%	10.3%
Time Maximization	---	8.1%	---	8.7%	---
Other	3.2%	4.1%	1.4%	2.6%	2.6%
Total Sample Size	561	148		195	

As shown in Figure 15, participants who showed a disposition towards an organization-based strategy consistently chose that strategy in the task, regardless of the time costs or benefits; likewise, those who favoured a search-only strategy also chose the search-only strategy without seeming to consider relative task time. However, those who preferred a time-minimization approach were more likely to choose strategies that required less time to complete the search task.

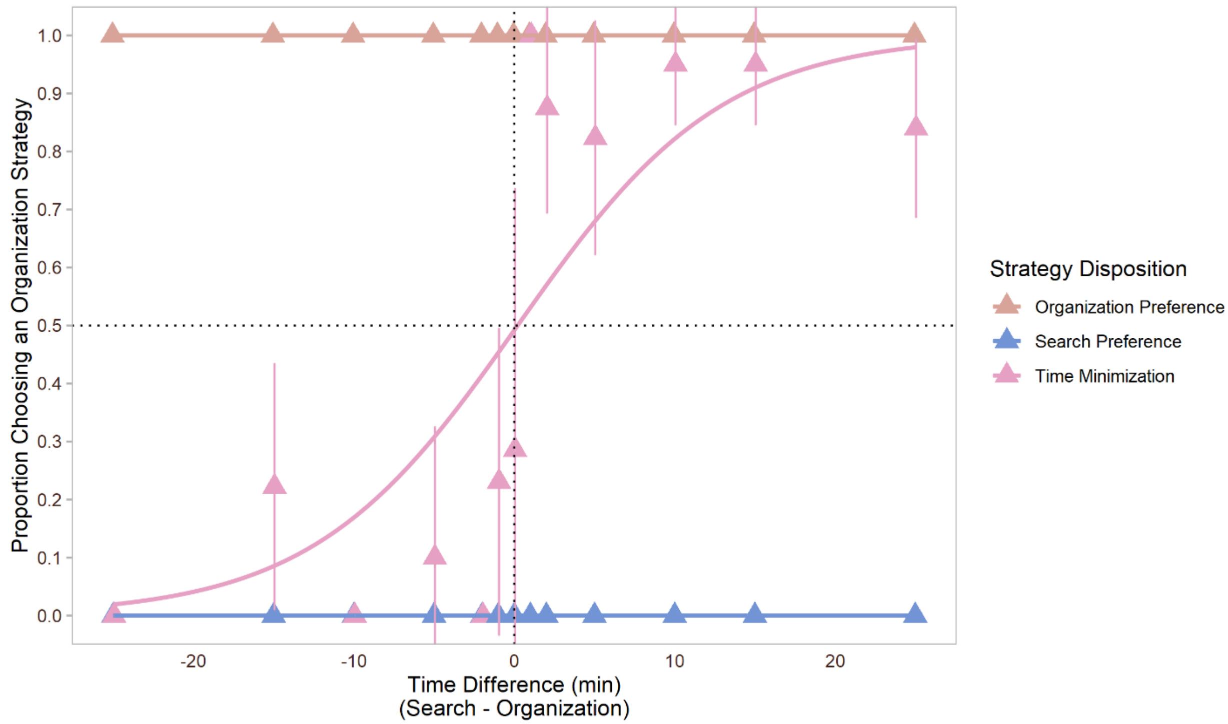


Figure 15. Strategy selection as a function of researcher-coded individual strategy dispositions in Study 7. Solid fit lines represent the estimated sigmoidal curve associated with each coded category. Error bars represent 95% confidence interval. The grey dotted horizontal line represents chance, and the grey dotted vertical line delineates the point where there is no time difference across the two strategies.

Next, I examined the relation between relative task time and strategy selection only for individuals who preferred to minimize time spent on task (i.e., time-minimizers)[4]. As summarized in Table 14, relative task time significantly predicted individuals' strategy selection,

[4] The interaction between individuals' reason for strategy selection and manipulated relative task time could not be assessed in this particular scenario since individuals who favour direct search or organization perfectly predict their choice selection. I did not analyze data from individuals in the "other" category, as there are too few observations (*N* = 18) for the results to be meaningful in a regression analysis. Further, separate logistic regressions were not conducted for organizers and searchers as there is no variance in individuals' strategy selection in these two groups and, as a result, the models would not be able to converge.

b = .16, 95% CI [.12, .21], z = 6.81, p < .001. Importantly, when relative time was held constant at 0, the model intercept was not significant, b = -.03, 95% CI [-.40, .33], z = .17, p = .86. In other words, time-minimizers did not seem to have any systematic preference for one strategy over another.

Table 14.

Logistic regression model using relative task time to predict strategy selection for time-minimizers only.

	Strategy Selection (Time-Minimizers Only)			
Predictors	*Log-Odds*	*CI*	*Statistic*	*p*
Intercept	-0.03	-0.40 – 0.33	-0.17	0.863
Relative Time	0.16	0.12 – 0.21	6.81	**<0.001**
Observations	200			
R^2 Tjur	0.452			

Finally, I wanted to examine whether time-minimizers picked their preferred task strategies based on how large the gain was for one strategy over another (i.e., a quantitative difference) or if their choices were simply based on the fact that one strategy was faster (i.e., a qualitative difference). To test this idea, I coded individuals' responses such that a time-minimizing choice (i.e., selecting the organization-based strategy if it was objectively faster) was coded as 1, whereas a choice inconsistent with minimizing task time was coded as 0. This was used as the criterion variable and absolute task time difference was used as the predictor variable. If the likelihood of selecting a strategy is graded, then I would expect there to be a positive relation between the two: as the relative gain of one strategy increases, individuals should be more likely to select that strategy. On the other hand, if the qualitative account were true, then I would not expect there to be a relationship between absolute time difference and individuals' tendency to select the time-minimizing strategy. As depicted in Figure 16 and Table 15, I found no difference between absolute time difference between the two strategies and the degree to which time-minimizers preferred the time-saving strategy in a logistic regression model, *b* = .004, 95% CI [-.05, .06], *z* = .15, *p* = .88. The model intercept was, however, significant, *b* = 2.16, 95% CI [1.43, 3.01], *z* = 5.42, *p* < .001. Taken together, time-minimizers seemed to favour whichever strategy was objectively faster, regardless of whether the faster strategy had 1 minute of time gain or 25 minutes.

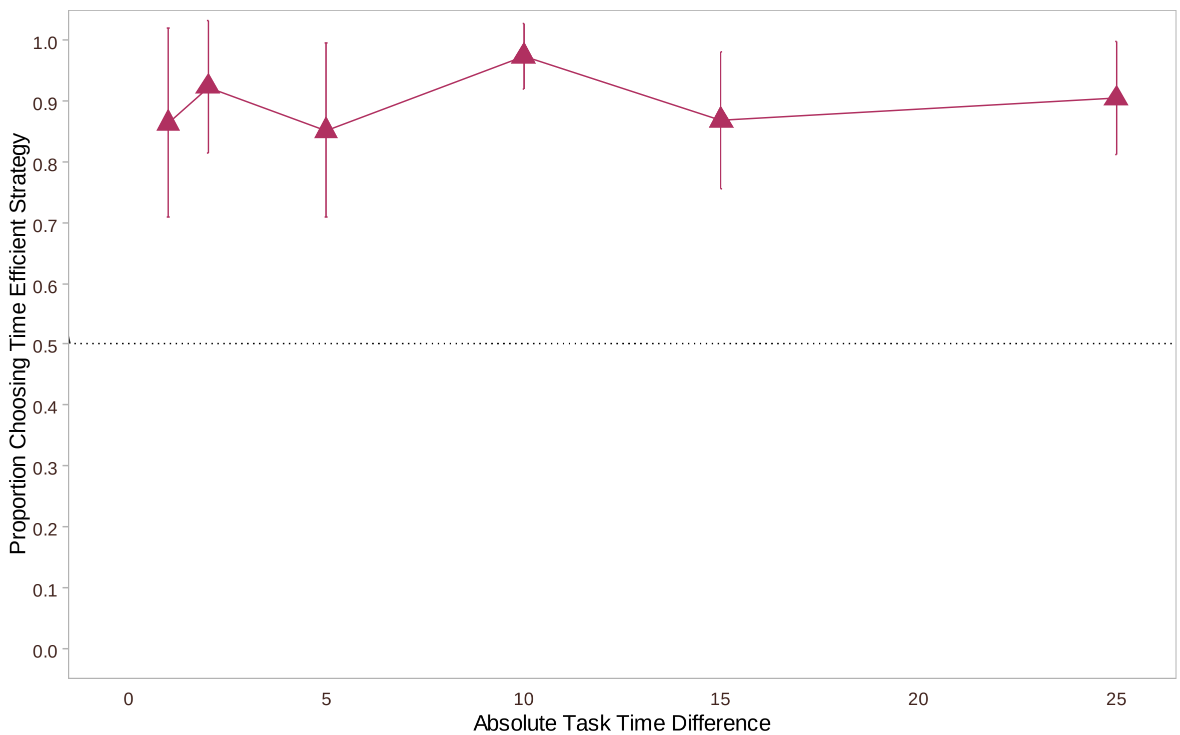


Figure 16. Proportion of time-minimizers who chose the more time efficient search strategy, as a function of absolute task time difference across the two strategies. Error bars represent 95% CI.

Table 15.

Logistic regression using absolute task time to predict the likelihood of time-minimizers chose a strategy that took objectively less time.

	Preference Consistent Strategy Selection			
Predictors	*Log-Odds*	*CI*	*Statistic*	*p*
Intercept	2.16	1.43 – 3.01	5.42	**<0.001**
Absolute Task Time Difference	0.00	-0.05 – 0.06	0.15	0.877
Observations	193			
R^2 Tjur	0.000			

Discussion

The results in Study 7 support a causal relation between task time and strategy selection; when the task time associated with each strategy was systematically manipulated, participants were more likely to select the strategy that was relatively more time efficient. Interestingly, the overall task length did not seem to play a significant role in strategy selection, though the results do seem to trend in the predicted direction (i.e., as task length increases, individuals may be more likely to engage in spatial organization). One possible explanation for this result is that it may require a larger range in task length than the range used in the study (e.g., days or weeks as opposed to minutes and hours) to have a sufficiently large influence on individuals' strategy selection. However, it is possible that the tendency to engage in organization-based search strategies do not depend on *overall* task length. Nevertheless, given that relative task time predicted strategy selection—while absolute task length did not—it would seem that relative task time was a far more salient consideration for individuals than other time indicators related to this task. One thing to note in the current results was that the model intercept, when only relative and absolute task time were included as predictors, demonstrated that individuals in the current sample were more likely to choose the organization-based strategy compared to the search-only strategy overall. I will return this point in greater detail later in the discussion.

In addition to an overall effect of relative task time, there was also evidence that individuals' pattern of strategy selection differed as a function of their reported strategy dispositions. For both organizers and searchers—individuals who preferred the organization-based or search-only strategy respectively—strategy selection was based entirely on whichever strategy they were disposed towards, regardless of the time cost or benefit associated with that strategy (i.e., searchers always chose the search-only strategy and organizers always chose the organization-based strategy). For time-minimizers who were primarily concerned with minimizing the amount of time they spend in the task however, relative task time significantly predicted which strategy they were more likely to select. Specifically, individuals were driven by qualitative differences in the more time-efficient strategy, as opposed to the degree to which one strategy would be faster than the other, as indicated by the lack of relation between the absolute difference in time gain and the likelihood for individuals to select the more time-efficient strategy.

Importantly, examining individual differences in strategy disposition helped to explain why individuals were more likely to select an organization-based strategy over a search-only strategy at the aggregate level. Recall that, in the model that contained absolute and relative task time as predictors, the model intercept (i.e., when relative task time was held constant at 0 and absolute base time was held constant at its mean) indicated that participants were significantly more likely to choose the organization-based strategy. When the data were broken down by individual differences in strategy disposition, time-minimizers did not appear to favour one strategy over another with relative task time held constant at 0. This means that time-minimizers could not have contributed towards the observed bias at the group level. However, as shown in Figure 15, both organizers and searchers consistently chose either an organization-based or search-only strategy. Since there were proportionally more organizers (46.2% of total sample) compared to searchers (15% of total sample), the overall tendency for individuals to select the organization-based strategy reflected the makeup of individual dispositions within the sample. However, the reported individual differences in strategy disposition in the current study may need to be interpreted with caution. Though individuals' strategy disposition may represent relatively stable inclinations towards a given strategy (Gosling et al., 2002), it is also possible that some individuals may conflate their strategy selections with a preference for that particular strategy. For instance, an individual who chose an organization-based strategy in a scenario when it is expected to take less time to complete the search task than a search-only strategy may attribute their motivation for that selection as their preference towards the organization-based strategy, when it may have reflected their desire to minimize task time. This may be particularly easy to do, given that individuals were only ever presented with a single scenario. As such, it may be worth examining whether the observed pattern of strategy selection across individuals with each type of strategy disposition would replicate when individuals are shown more than one scenario.

Study 8

In Study 7, it was demonstrated that manipulating differences in relative task time led individuals to pick whichever strategy was more time efficient at the aggregate level. However, upon closer inspection of the data, it appeared that this effect was limited to individuals who were motivated to minimize time spent on task. On the other hand, individuals with a disposition towards either the organization-based or search-only strategies always chose the strategy that matched their strategy preference, regardless of the relative time cost or gain associated with that particular strategy.

In the current study, I aimed to replicate these findings in a within-subjects design in which participants made strategy selections in multiple scenarios that vary in the time cost associated with a given strategy. As there was a lack of evidence in the previous study that overall task length affected individuals' strategy selection, the current study was largely focused on examining the effect of relative task time; rather than providing individuals with how many minutes each strategy took to complete the task, participants were, instead, provided with the relative gain or cost between the two strategies.

In addition to elaborating upon their motivation for making their pattern of strategy selection in an open-ended response, as done in Study 7, participants were also asked to self-select which motivation best described their strategy selection based on the coder-derived categories from Study 7 (i.e., a motivation to reduce overall task time, to avoid organization regardless of task time, or a preference towards organization regardless of task time). In addition to these 3 categories, a fourth choice—a desire to maximize time spent on the task—was included. This choice was included as it was shown in Chapter 3 that individuals tended to choose whichever strategy was perceived to be more enjoyable. That is, it is possible that some individuals may want to spend more time on the task because they enjoy doing so, but do not necessarily have a preference for either strategy. Having participants self-select which of these 4 reasons best described their pattern of strategy selection helps to reduce any ambiguity in the interpretation of individuals' motivation.

Method

Participants

A total of 200 participants were recruited through Amazon Mechanical Turk to complete this study. Participants were restricted to those living in the United States. Of the total sample, 87 identified as female and 112 identified as male; 1 participant did not report their gender. The mean age of this sample was 34.11 years (*SD* = 10.48); 1 participant did not report their age. Participants were given $0.67 USD in exchange for their participation. They provided their informed consent before beginning the study and were debriefed upon completing the study. Ethical approval for the study was obtained from the Research Ethics Board at the University of Waterloo.

Design

Task time was manipulated across 3 levels of relative task time (-25, 0, 25) in a within-subjects design.

Task Procedure & Design

As with Study 7, participants were given hypothetical search scenarios involving Lego building blocks. In this study, however, participants were asked to complete 3 scenarios instead of one. Unlike in Study 7 wherein participants were told how many minutes each strategy would take to complete the task, participants in this study were given a *relative* task time difference between the two strategies. Specifically, participants were told that the organization-based strategy was either expected to take 25 minutes more, 25 minutes less, or the same amount of time as the search-only strategy. These scenarios were provided one by one, in random order, and participants selected their preferred strategy for each scenario separately. After the scenarios, participants were asked to select one of 4 reasons that best described their strategy selections in the 3 scenarios: (1) preferring organization, regardless of how long it would take, (2) preferring to directly search for the pieces, regardless of how long it would take, (3) preferring whichever strategy would minimize time, or (4) whichever strategy that would maximize time (i.e., prolong the task). The placements of these choices were randomized across individuals. If none of these options captured the strategy that the participants used, they were provided with an "other" option that was placed in the last position, where they could describe the particular strategy that they used. In addition to selecting a reason, participants were given an open-ended response box and asked to elaborate on their reason for selecting their strategies. Once participants finished this section, they were directed to the debriefing page.

Results

Exclusion

I employed the same exclusion criteria as Study 7. No participants were excluded due to duplicate worker IDs. However, participants who provided unusual responses (N = 47) or no response at all (N = 5) for the open-ended response question were excluded, leaving 148 participants for the analysis.

Analysis

Since the same participant completed multiple scenarios, I used the *geepack* package in R to conduct generalized estimation equations in order to account for the within-subject variance in the data (Halekoh, Højsgaard, & Yan, 2006). Unlike mixed-effects models, which model random effects structures (e.g., participant) in order to account for non-independent observations, generalized estimation equations will model participants as a nuisance variable, but not provide an estimate for this factor. As the effect of participants can be quite small in the context of the current study (i.e., leading to model non-convergence when it was included as a random effect in mixed-effects models), and because the primary focus was to account for the same individuals making multiple strategy selections throughout the study, using generalized estimation equations was an ideal alternative to mixed-effects models. The default covariance structure was used across all models and robust standard error was used to obtain 95% confidence intervals.

Strategy Selection

I examined the relation between relative task time and individuals' strategy selection using generalized estimation equations. A negative time difference score indicated that the search-only strategy was faster than the organization-based strategy, and vice versa. Relative task time was a significant predictor of individuals' strategy preference, $b = .06$, 95% CI [.05, .07], Wald $\chi^2 = 92.91$, $p < .001$. The model intercept when relative task time was at 0 was also significant such that individuals were generally more likely to select an organization-based strategy even when it was not associated with a time benefit, $b = .24$, 95% CI [.02, .46], Wald $\chi^2 = 4.74$, $p = .03$.

Individual Disposition Towards A Given Strategy

The proportions of individuals with each strategy disposition are depicted in Table 13. First, the relation between individual dispositions and strategy selection was analyzed. Here, I used individuals' self-selected disposition categories for the analysis. A model using generalized estimation equations was constructed, with relative task time and strategy disposition (categorical variable with time-minimizers at the reference level), as well as the interaction between these two factors, to predict the likelihood that individuals would select an organization-based strategy over a search-only one. Figure 17 shows a graphical depiction of this model. Note that individuals who self-selected the "other" category were excluded from this analysis as there were too few observations. It was found that the model intercept was not significant, $b = .25$, 95% CI [-.09, .60], Wald $\chi^2 = 2.03$, $p = .15$, indicating that time-minimizers were no more likely to choose a search-only strategy compared to an organization-based strategy. Indeed, time-minimizers were more likely to choose whichever strategy took less time, *b* = .10, 95% CI [.08, .13], Wald χ^2 = 77.03, p <.001. Compared to time-minimizers, organizers were overall significantly more likely to choose an organization-based strategy, *b* = 1.84, 95% CI [.98, 2.70], Wald χ^2 = 17.52, $p < .001$, whereas searchers were overall significantly more likely to choose a search-only strategy, *b* = -2.28, 95% CI [-3.18, -1.38], Wald χ^2 = 24.86, $p < .001$. However, time-maximizers did not differ significantly from time-minimizers in the likelihood of choosing an organization-based strategy as a function of relative task time, *b* = -.12, 95% CI [-.91, .68], Wald χ^2 = .08, p = .77.

When the difference between slopes were examined by looking at each of the two-way interaction terms, the rate of change in time-minimizers' likelihood for selecting one strategy over another was significantly steeper compared to organizers, *b* = -.07, 95% CI [-.12, -.02], Wald χ^2 = 8.55, p = .003, searchers, *b* = -.08, 95% CI [-.13, -.04], Wald χ^2 = 14.02, $p < .001$, and time-maximizers, *b* = -.06, 95% CI [-.10, -.02], Wald χ^2 = 7.28, p = .01. I then constructed separate models using generalized estimation equations to examine whether relative task time would predict strategy selection within each of these groups of individuals. Relative task time did not predict strategy selection among organizers, *b* = 0.03, 95% CI [-.01, .07], Wald χ^2 = 1.68, p = .19, nor searchers, *b* = .02, 95% CI [-.02, .06], Wald χ^2 = 1.14, p = .29. However, relative task time was a significant predictor for time-maximizers, though not in the same direction as would be expected (in fact, they preferred the strategy that would lead them to spend more time in the task, rather than less), *b* = .04, 95% CI [.01, .08], Wald χ^2 = 5.60, p = .02. See Table 16 for a summary of the results separated by strategy disposition.

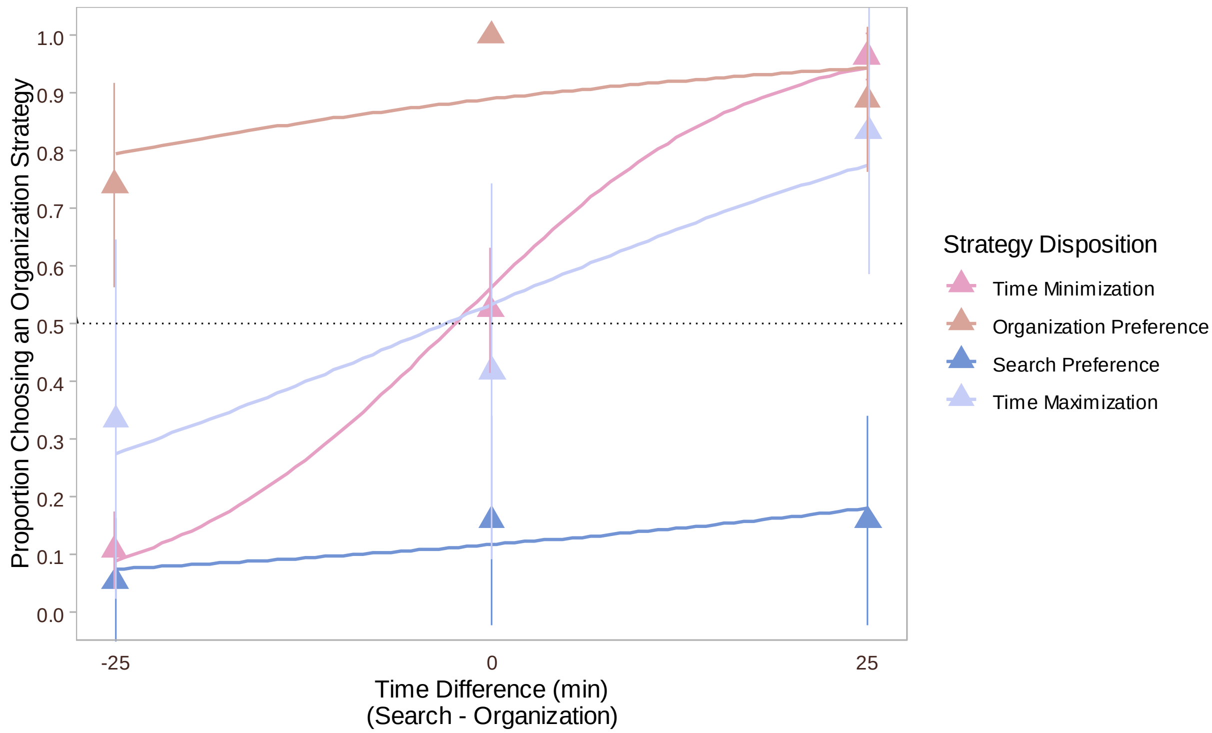


Figure 17. Strategy preference as a function of participants' self-selected strategy disposition in Study 8. Solid lines represent the estimated sigmoidal curve associated with each coded category. Error bars represent 95% confidence intervals. The grey dotted line represents chance.

Table 16.

Logistic regression using generalized estimation equation to predict strategy selection using relative task time separately for each of the self-selected strategy disposition categories in Study 8.

	Organizers			**Searchers**			**Time-Minimizer**			**Time-Maximizer**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	2.09	1.30 – 2.88	**<0.001**	-2.03	-2.86 – -1.20	**<0.001**	0.25	-0.09 – 0.60	0.154	0.13	-0.58 – 0.85	0.714
Relative Time	0.03	-0.01 – 0.07	0.194	0.02	-0.02 – 0.06	0.286	0.10	0.08 – 0.13	**<0.001**	0.04	0.01 – 0.08	**0.018**
N	27_{ID}			19_{ID}			84_{ID}			12_{ID}		
Observations	81			57			252			36		

Note. The ID label reported in the table indicate the nuisance variable that was entered in the model to allow the generalized estimation equations to estimate the covariance structure.

One thing that stood out in these results was that although the rate at which task time difference affected the likelihood of individuals choosing the organization-based strategy differed between time-minimizers and -maximizers, both groups of individuals showed largely the same pattern of results (i.e., choosing whichever strategy would be more time efficient). As such, it is possible that participants misconstrued the "time-maximization" option and may have interpreted "maximizing time" to mean spending time efficiently when performing the task (i.e., to reduce or minimize time spent performing the search task). To address this possibility, two independent coders again labelled individuals as one of 4 category labels based on their open-ended responses: (1) time-minimizers, (2) organizers, (3) searchers, and (4) others. The inter-rater reliability between the coding was moderately high (k = .76). As with Study 7, a third coder resolved any conflicts when the coding provided by the first two coders differed. The proportion of individuals with each researcher-coded strategy disposition can be found in Table 13. An alluvial diagram (Figure 18) was constructed to depict similarities across the participants' self-selected (left side) and researcher-coded strategy dispositions (right side). Indeed, the vast majority of individuals who self-selected the "maximize time" option was coded by coders as time-minimizers.

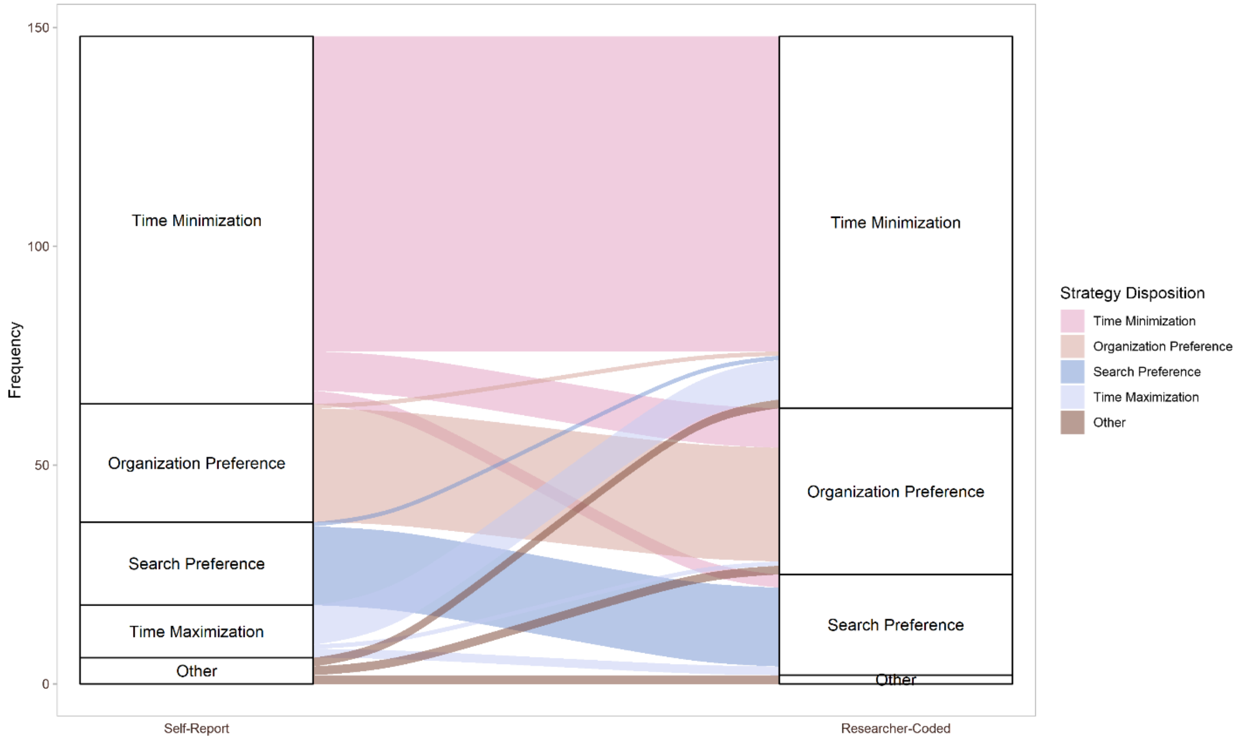


Figure 18. Mapping of participants' self-reported disposition (left) to their researcher-coded counterpart (right) in Study 8.

Since participants' self-selected categories may not be an accurate reflection of their strategy disposition, I conducted the same analysis looking at the relation between strategy selection and researcher-coded dispositions. As shown in Figure 19, participants' pattern of strategy selection when broken down by researcher-coded strategy disposition were similar to their self-reported counterparts. A model using generalized estimation equations again revealed that when there was no difference in task time across strategies, time-minimizers were no more likely to select the organization-based strategy over the search-only strategy, b = .13, 95% CI [.20, .47], Wald χ^2 = .60, p = .44, but were strongly influenced by relative task time, b = .10, 95% CI [.07, .12], Wald χ^2 = 75.90, p < .001. Organizers were more likely than time-minimizers to select the organization-based strategy, b = 1.98, 95% CI [1.09, 2.87], Wald χ^2 = 18.97, p < .001, and searchers were more likely than time-minimizers to select the search-only strategy, *b* = -1.90, 95% CI [-2.68, -1.11], Wald χ^2 = 22.49, *p* < .001. Although there was a difference in how sensitive time-minimizers were to relative time difference compared to searchers, *b* = -.07, 95% CI [.-11, -.03], Wald χ^2 = 10.78, *p* < .001, there was, interestingly, no significant difference between organizers and time-minimizers in how sensitive they were to task time, *b* = -.03, 95% CI [-.08, .02], Wald χ^2 = 2.08, *p* = .15. Follow-up models were conducted separately for organizers and searchers. It was found that relative task time was a significant predictor for organizers, *b* = .06, 95% CI [.02, .10], Wald χ^2 = 8.90, *p* = .003, but not for searchers, *b* = .03, 95% CI [-.01, .06], Wald χ^2 = 2.33, *p* = .13. The results for individuals coded into each of the dispositions can be found in Table 17.

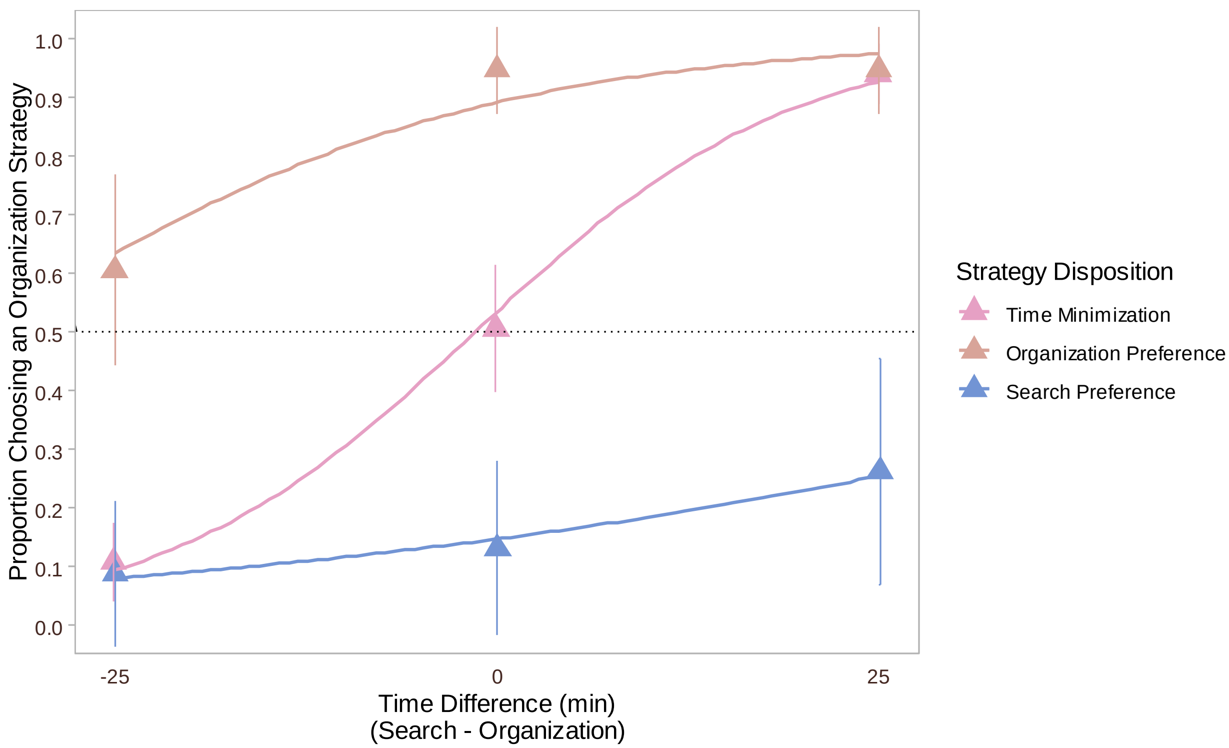


Figure 19. Strategy preference as a function of researcher-coded strategy disposition in Study 8. Solid lines represent the estimated sigmoidal curve associated with each coded category. Error bars represent 95% confidence intervals. The grey dotted line represents chance.

Table 17.

Logistic regression using generalized estimation equation to predict strategy selection using relative task time separately for each of the rater-coded strategy disposition categories in Study 8.

	Organizers			**Searchers**			**Time-Minimizers**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	2.11	1.28 – 2.93	**<0.001**	-1.77	-2.48 – -1.06	**<0.001**	0.13	-0.20 – 0.47	0.439
Relative Time	0.06	0.02 – 0.10	**0.003**	0.03	-0.01 – 0.06	0.127	0.10	0.07 – 0.12	**<0.001**
N	38 ID			23 ID			85 ID		
Observations	114			69			255		

Note. The ID label reported in the table indicate the nuisance variable that was entered in the model to allow the generalized estimation equations to estimate the covariance structure.

Exploratory Analyses

It may be worth noting that, compared to Study 7, there were proportionally more time-minimizers in the current study. This was reflected in both participants' self-selected and coder-derived strategy dispositions (see Table 13). Indeed, a chi-squared test of independence revealed that there was a significant association between category labels across the two studies, $\chi^2(3) = 27$, $p < .001$. These results are consistent with the idea that more individuals may have conflated their strategy selection with reported strategy disposition when presented with a single scenario. However, given that there were also far more time-minimizers in the current study as opposed to

Study 7, it may be that showing participants multiple scenarios varying in the time cost associated with a given strategy made relative task time a more salient factor in the study.

To follow up on this observation, I tested the idea that a within-subjects design would highlight task time by comparing how sensitive individuals were to manipulations of task time in their strategy selection made in the first scenario (i.e., when they have had no exposure to prior scenarios) compared to the last (i.e., after being exposed to multiple other scenarios). If relative task time was more salient to participants after they were exposed to multiple scenarios, then individuals would be more sensitive to relative task time manipulations (i.e., have a steeper slope) in their response to the final scenario (i.e., after exposure to two other scenarios prior) compared to in the first one (i.e., having no prior exposure to other scenarios at all). A model using generalized estimation equations was constructed, with relative task time, scenario (first vs. last), and their interaction term predicting individuals' strategy selection. Figure 20 shows a depiction of the data. There was a marginally significant interaction, $b = .03$, 95% CI [-.001, .06], Wald $\chi^2 = 3.71$, $p = .054$. The interaction trended in the predicted direction, with relative task time having a marginally flatter slope in the first scenario, $b = .05$, 95% CI [.03, .06], Wald $\chi^2 = 24.55$, $p < .001$, compared to the last scenario, $b = .08$, 95% CI [.05, .10], Wald $\chi^2 = 41.68$, $p < .001$. Table 18 provides a summary of the results.

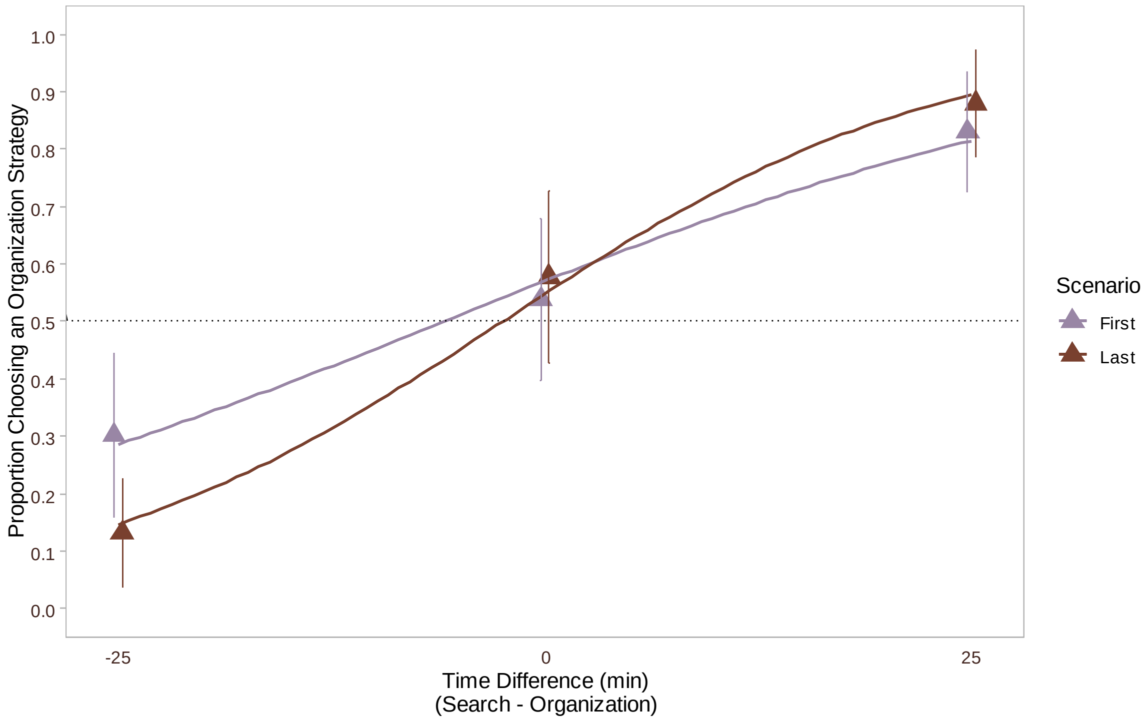


Figure 20. Mean proportion of individuals choosing the organization-based search strategy as a function of relative task time and scenario (first vs. last) in Study 8. Solid lines represent the estimated sigmoidal curve associated with each condition. Error bars represent 95% confidence intervals. The grey horizontal dotted line represents chance.

Table 18.

Logistic regression using generalized estimation equation to predict strategy selection using relative task time separately for the first vs. last scenario in the task Study 8.

	First			**Last**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	0.279	-0.082 – 0.640	0.130	0.184	-0.235 – 0.603	0.390
Relative Time	0.048	0.029 – 0.067	**<0.001**	0.078	0.054 – 0.102	**<0.001**
N	148 ID			148 ID		
Observations	148			148		

Note. The ID label reported in the table indicate the nuisance variable that was entered in the model to allow the generalized estimation equations to estimate the covariance structure.

Discussion

At the aggregate level, individuals tended to select whichever strategy they deemed to be more time efficient overall but were more likely to select the organization-based strategy over the search-only strategy when there was no benefit of time for either strategy. When these results were broken down by individuals' strategy disposition, relative task time was a significant predictor among time-minimizers and organizers, but not searchers. For both organizers and searchers, individuals were far more likely to select their preferred strategy regardless of the cost or benefit in task time, whereas time-minimizers only selected strategies that were associated with a reduction in task time. The fact that relative task time was a significant predictor of strategy selection among organizers contrasts with the results in Study 7, wherein organizers always chose the organization-based strategy. This may suggest that when relative time costs become more salient as a result of exposed to multiple scenarios, individuals with strong strategy dispositions can become sensitive to this factor.

Interestingly, by having individuals make strategy selections across multiple scenarios that differed in relative time costs associated with each strategy, participants may have become more sensitive to task time as a result. Firstly, individuals became more sensitive to manipulations of relative task time after increased exposure to multiple other scenarios compared to when there was no prior exposure, as reflected in their pattern of strategy selection. However, this interaction was only marginally significant, suggesting that there may be somewhat of a ceiling effect. That is, time may already be a salient consideration for individuals during strategy selection; thus, highlighting differences in the relative time costs across scenarios may only result in a small increase in individuals' sensitivity to this factor. Further evidence for the notion that relative task time was made more salient is that participants in the current study were significantly more likely to identify (and be identified by coders) as being time-minimizers compared to in Study 7. This shift in individuals' reported dispositions may suggest that while some individuals do truly have dispositions towards a given strategy (e.g., reflecting a stable personality trait; Gosling et al., 2002), others may not, and their motivations may represent post-hoc reasons for their pattern of strategy selection earlier on in the task. Despite the shift in the proportion for each strategy disposition across studies, there were still proportionally more organizers compared to searchers in the current study. This ratio of organizers to searchers is again consistent with the observation that individuals tended to select the organization-based strategy over the search-only strategy even though there was no benefit of task time in doing so (i.e., when the relative task time across strategies was 0). Despite the apparent difference between Study 7 (in which a single scenario with differing time costs was shown) and the current study (in which multiple scenarios were shown), 25% of respondents in the current study were removed. This may bring into question the quality of the data, as well as statistical power. As such, I decided to replicate these findings using a separate sample in the following experiment.

Study 9

In addition to replicating the results of Study 8, the added aim of the current study is to examine whether individual dispositions towards a given search strategy may reflect more domain-general tendencies. Specifically, I examined whether self-identified organizers may also report a greater level of organization in other aspects of their lives, and if self-reported organization may explain individuals' strategy selection. If one's strategy preferences reflect more general tendencies in the way one arranges one's space, then I would expect that individuals who report having more organized spaces may also tend to choose an organization-based strategy over a search-only strategy.

Method

Participants

A total of 200 participants living in the United States were recruited through Amazon Mechanical Turk and completed this study. Of the total sample, 93 participants identified as female, 106 identified as male, and 1 participant identified as non-binary. The mean age of this sample was 35.72 years (*SD* = 11.11). Participants were given $1.05 USD in exchange for their participation. As a screening and data quality measure, participants completed a CAPTCHA check after reading the information letter but before completing the consent form. If participants completed the CAPTCHA task successfully, they were directed to the consent page and provided their informed consent before beginning the study. Upon completing the study, participants were directed to a debriefing page that explained the purpose of the study. Ethical approval for the study was obtained from the Research Ethics Board at the University of Waterloo.

Design

Task time was manipulated across 3 levels of relative task time (-25, 0, 25) in a within-subjects design.

Task Procedure & Design

The study procedure was identical to Study 8 except for two added questions at the end of the study. Participants were asked to use a 6-point Likert scale to indicate, in general, how organized their workspace and living space were. respectively. The Likert scales had only anchor labels at each end of the scale, with "not at all organized" at one end and "extremely organized" on the other.

Results

Exclusion and Statistical Analysis

The exclusion criteria were identical to that in Studies 7 and 8. No participants were excluded due to duplicate worker IDs; 5 participants provided unusual responses when asked to elaborate on their reason for their strategy selection and were removed from analysis, thus, data from 195 participants were analyzed. The statistical analysis procedure and tools were the same as in Study 8. Wherever appropriate, the *ez* package was used to conduct ANOVA (Lawrence, 2016), and generalized eta-squared (η^2_G) values are reported along with *p*-values.

Strategy Selection

As with Study 8, a model using generalized estimation equations was constructed wherein relative task time was used to predict individuals' strategy selection across different scenarios. Relative task time was a significant positive predictor of individuals' strategy selection, $b = .07$, 95% CI [.06, .08], Wald $\chi^2 = 139.30$, $p < .001$. The model intercept was also significant, $b = .53$, 95% CI [.32, .74], Wald $\chi^2 = 25.50$, $p < .001$.

Individual Disposition Towards A Given Strategy

Although individuals were still asked to self-select the motivation that best matched their pattern of strategy selection in the current study, this information was not used for the current analysis due to issues already addressed in the previous study. Instead, researcher-coded strategy dispositions were used. Like in Studies 7 and 8, independent coders categorized participants based on their open-ended responses into one of 4 categories: (1) time-minimizers, (2) organizers, (3) searchers, and (4) others. The inter-rater reliability between the two coders was substantial (*k* = .81). A third coder resolved any conflicts when the coding provided by the first two coders differed. The proportion of individuals in each self-selected and researcher-coded strategy disposition category can be found in Table 13.

As with Study 8, participants in the current study were significantly more likely to be categorized by coders as time-minimizers than in Study 7 wherein only a single scenario was presented. A chi-squared test of independence confirmed that there was a significant relation between category labels across experiments, $\chi^2(3) = 49$, p < .001.

Next, I examined how individuals' strategy selection differed as a function of researcher-coded strategy dispositions.[5] A visual depiction of the results are shown in Figure 21. A model using generalized estimation equations was constructed; both self-reported strategy disposition, relative task time, as well as their interaction were included in the model. As with previous studies, participants who selected the "other" category were removed from this analysis. Time-minimizers were dummy coded to be the reference level with which individuals with all other strategy dispositions were compared against. There was a non-significant model intercept, *b* = .24, 95% CI -.06, .55], Wald χ^2 = 2.44, *p* = .12, indicating that time-minimizers were overall no more likely to choose one strategy over another. However, relative time difference was a significant predictor for time-minimizers alone, *b* = .12, 95% CI [.09, .14], Wald χ^2 = 99.76, *p* <.001. Compared to time-minimizers, organizers were, overall, significantly more likely to choose an organization-based strategy, *b* = 3.69, 95% CI [1.93, 5.46], Wald χ^2 = 16.80, *p* < .001. On the other hand, searchers were, overall, more likely to choose a search-only strategy, *b* = -1.67, 95% CI [-2.50, -.85], Wald χ^2 = 15.87, *p* < .001.

[5] I also ran the same analysis using participants' self-selected categories. The general pattern of results did not differ.

When examining differences in slopes across different groups of individuals, the rate of change in time-minimizers' likelihood for selecting one strategy over another was significantly steeper compared to searchers, b = -.06, 95% CI [-.11, -.02], Wald χ^2 = 7.02, p = .008, but not for organizers, b = -.01, 95% CI [-.09, .06], Wald χ^2 = .15, p = .70. Follow-up generalized estimation equations were conducted for individuals with different strategy dispositions aside from time-minimizers. Relative task time was a significant predictor among both organizers, b = .10, 95% CI [.03, .18], Wald χ^2 = 7.60, p = .006, and searchers, b = .06, 95% CI [.02, .10], Wald χ^2 = 9.14, p = .003. A summary of the results, broken down by individual disposition, is shown in Table 19.

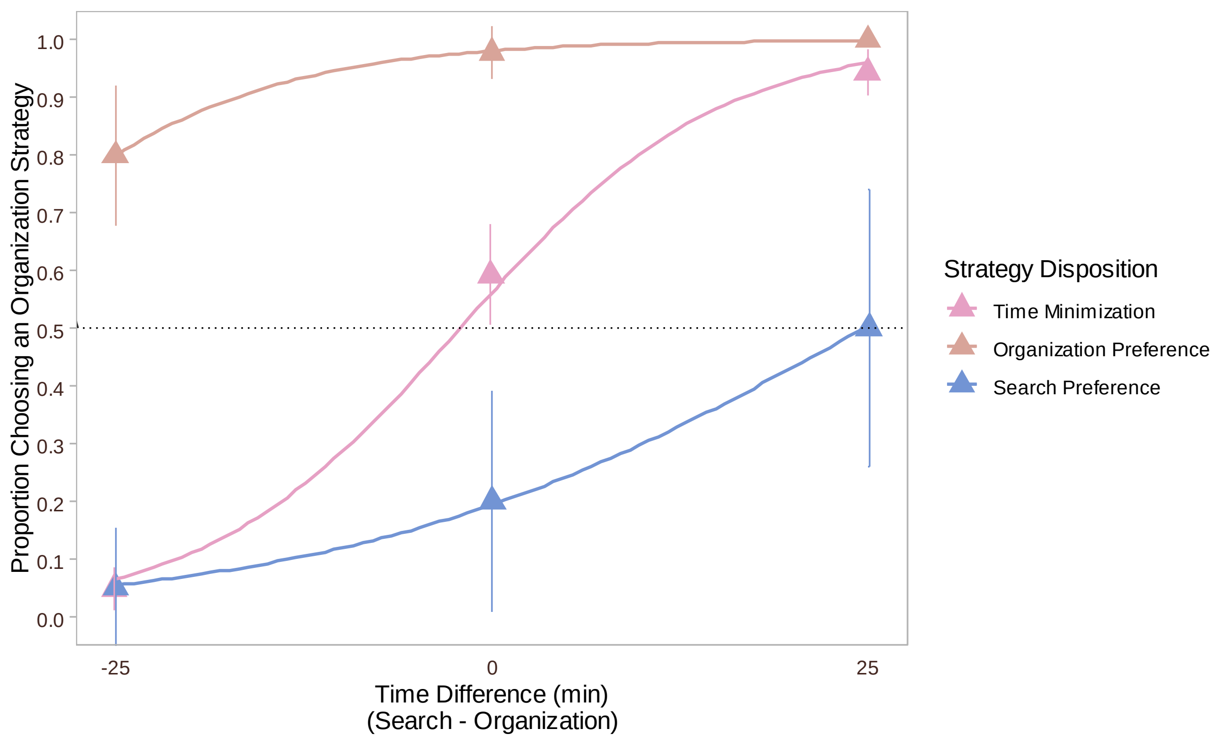


Figure 21. Strategy preference as a function of researcher-coded individual strategy disposition in Study 9. Solid lines represent the estimated sigmoidal curve associated with each coded category. Error bars represent 95% confidence intervals. The grey dotted line represents chance.

Table 19.

Logistic regression using generalized estimation equation to predict strategy selection using relative task time separately for each of the rater-coded strategy disposition categories in Study 9.

	Organizers			**Searchers**			**Time-Minimizers**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	3.93	2.20 – 5.67	**<0.001**	-1.43	-2.19 – -0.67	**<0.001**	0.24	-0.06 – 0.55	0.118
Relative Time	0.10	0.03 – 0.17	**0.006**	0.06	0.02 – 0.10	**0.003**	0.12	0.09 – 0.14	**<0.001**
N	45 ID			20 ID			125 ID		
Observations	135			60			375		

Note. The ID label reported in the table indicate the nuisance variable that was entered in the model to allow the generalized estimation equations to estimate the covariance structure.

Strategy Selection as a Function of Prior Task Exposure

A model using generalized estimation equations was used to examine how individuals' strategy selection varied as a function of relative task time across the first and last scenario that was presented to them. Figure 22 shows a graphical representation of the data. There was a marginally significant interaction between scenario (first vs. last) and relative task time, $b = .03$, 95% CI [-.001, .05], Wald $\chi^2 = 3.48$, $p = .06$. Specifically, relative task time had a marginally weaker influence on individuals' strategy selection in the first scenario, $b = .05$, 95% CI [.03, .07], Wald $\chi^2 = 31.77$, $p < .001$, compared to individuals' strategy selection in the last scenario, *b* = .08, 95% CI [.05, .10], Wald χ^2 = 46.01, *p* < .001. Table 20 provides a summary of these results.

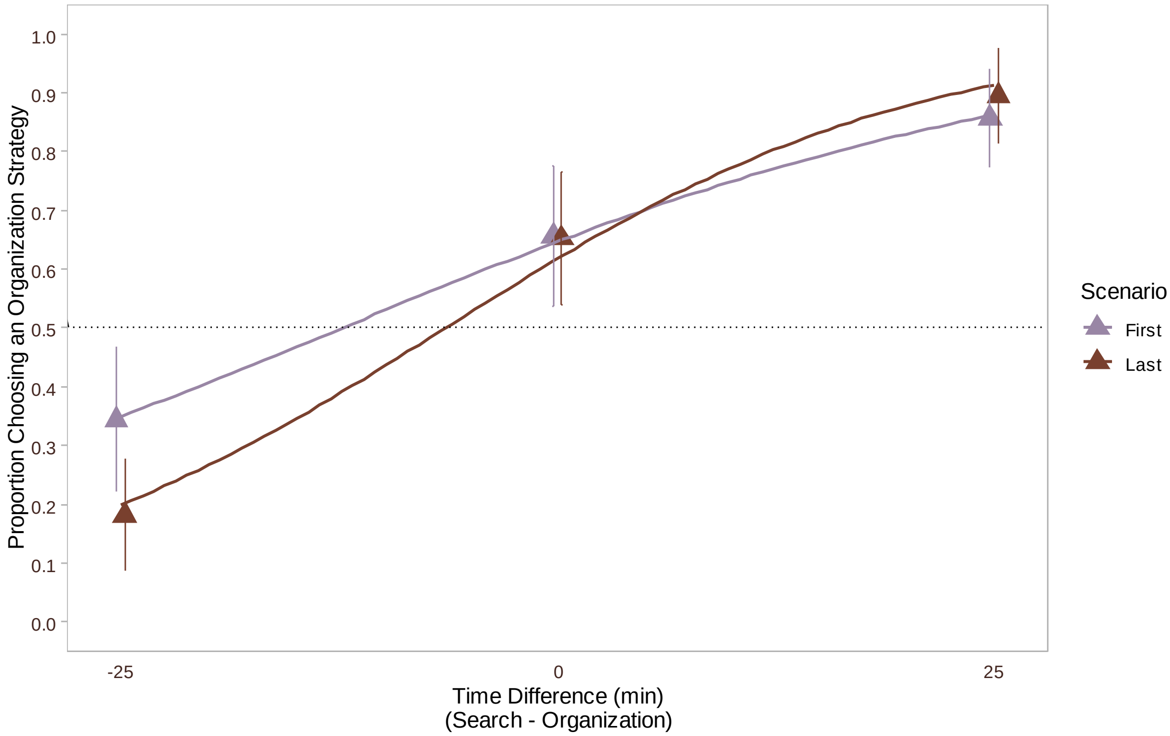


Figure 22. Mean proportion of individuals choosing organization-based search strategy as a function of relative task time and scenario (first vs. last) in Study 9. Solid lines represent the estimated sigmoidal curve associated with each condition. Error bars represent 95% confidence intervals. The grey horizontal dotted line represents chance.

Table 20.

Logistic regression using generalized estimation equation to predict strategy selection using relative task time separately for the first vs. last scenario in the task Study 9.

	First			**Last**		
Predictors	*Log-Odds*	*CI*	*p*	*Log-Odds*	*CI*	*p*
Intercept	0.604	0.274 – 0.933	**<0.001**	0.493	0.125 – 0.861	**0.009**
Relative Time	0.049	0.032 – 0.066	**<0.001**	0.075	0.054 – 0.097	**<0.001**
N	195_{ID}			195_{ID}		
Observations	195			195		

Note. The ID label reported in the table indicate the nuisance variable that was entered in the model to allow the generalized estimation equations to estimate the covariance structure.

Domain Specificity of Strategy Preference

One notion I aimed to investigate in the current experiment was whether one's general tendency or preference towards a given strategy reflects a more general preference for or against spatial organization. I examined this idea in two ways. First, I looked at whether individual differences in researcher-coded strategy disposition mapped on to participants' self-reported level of organization in their living and workspaces. To do so, a mixed-design ANOVA was conducted with researcher-coded strategy disposition as a between-subject factor and type of space (living vs. workspace) as a within-subject factor using type III sums of squares. As shown in Figure 23, there was a significant main effect of strategy disposition, $F(2, 187) = 8.20$, $p < .001$, $\eta^2_G = .07$. However, there was no main effect of space type, $F(1, 187) = 1.22$, $p = .27$, η^2_G

< .001, nor was there a significant interaction, $F(2, 187) = .14$, $p = .87$, $\eta^2_G < .001$. A post-hoc test was conducted to follow up on the significant main effect of strategy disposition using Tukey's HSD; Tukey-adjusted *p*-values were reported for a family of 3 estimates. Results revealed that organizers differed significantly from both time-minimizers, $p = .004$, and searchers, $p < .001$; there was no difference between time-minimizers and searchers in their level of reported spatial organization, $p = .18$.

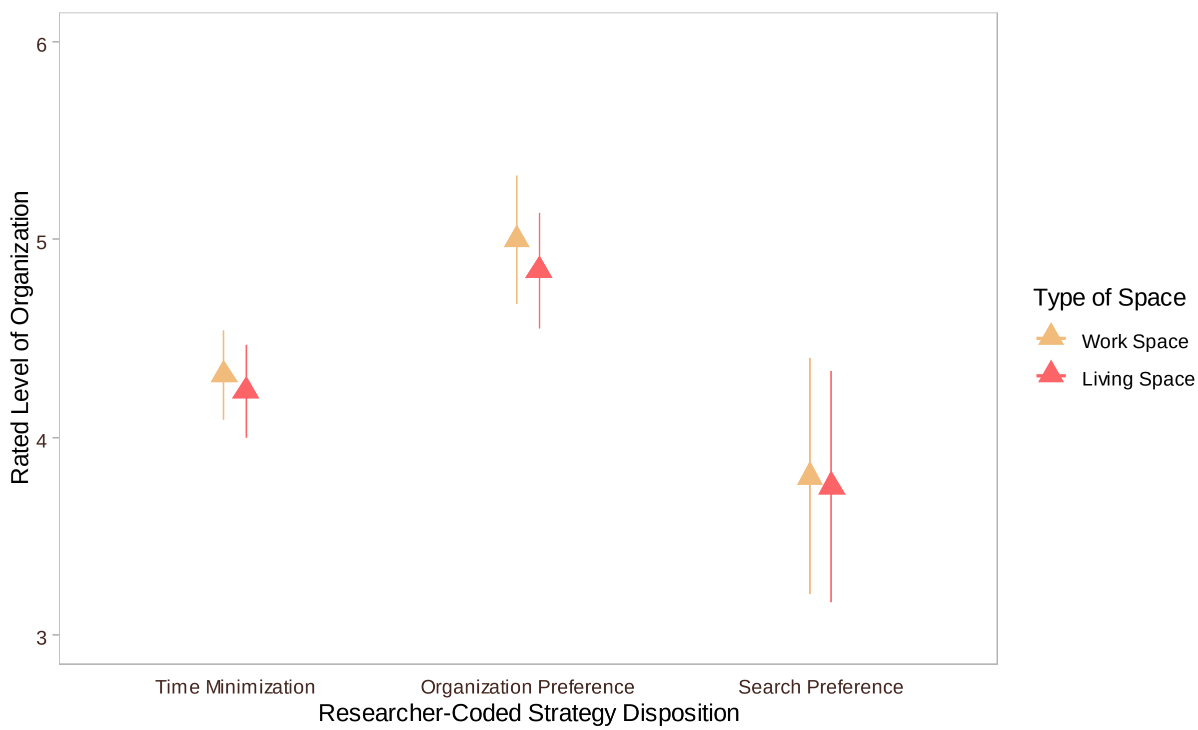


Figure 23. Mean self-reported organization ratings in living and workspaces as a function of self-reported strategy disposition. Error bars represent 95% confidence intervals.

Secondly, I examined whether it was possible to predict which strategies individuals would select across different scenarios using their self-reported level of spatial organization. To do so, individuals' average organization ratings across contexts (i.e., living and workspaces) were mean-centered and used as a predictor in a model that employed generalized estimation equations, along with relative task time and their interaction term. In addition to relative task time being a significant predictor of strategy selection, b = .07, 95% CI [.06, .08], Wald χ^2 = 131.45, p < .001, individuals who self-reported being more organized in their everyday spaces were also more likely to choose an organization-based search strategy, b = .48, 95% CI [.30, .66], Wald χ^2 = 27.05, p < .001. However, the interaction between self-reported organization and relative task time was not significant, b = -.005, 95% CI [-.01, .005], Wald χ^2 = .96, p = .33.

Discussion

A number of the main findings from Study 8 were replicated in the current study. Firstly, relative task time predicted individuals' strategy selection, and there was an overall tendency for individuals to select the organization-based strategy despite there being no time difference between the two strategies. This latter tendency could, again, be explained by the fact that there were more organizers in the sample compared to searchers. Secondly, like in Study 8, there was a marginal interaction between relative task time and whether individuals had prior exposure to other scenarios. Thirdly, individuals more frequently reported being motivated by time-related considerations in the current experiment when time costs across scenarios were made more salient, compared to when only a single scenario was presented to them in Study 7.

Although relative task time was a strong predictor of strategy selection among time-minimizers, time was also a significant (but comparatively weaker) predictor among organizers and searchers in the current experiment. Compared to the previous study, these results provide stronger evidence that individuals' strategy selection is tied to time-based performance considerations, at least when the time costs of a given strategy is made more apparent.

In addition to replicating Study 8, I also examined the degree to which preferences for a given strategy in the current search task might reflect more domain general tendencies. Indeed, self-reported organizers also reported having more organized spaces overall compared to both time-minimizers and searchers. Further, those who reported being more organized were also more likely to choose an organization-based search strategy. Altogether, these results suggest that one's tendency to choose to organize one's task environment in a seemingly limited context, such as a Lego search task, does appear to be a more domain general preference for spatial organization.

General Discussion

In Chapters 2 and 3, I presented evidence that individuals' strategy selection was related to the relative task time difference between each available strategy. These results, while consistent, reflect a correlation between *perceived* time-based performance benefits associated with adopting an organization-based strategy. As such, individuals' estimated task time may reflect inherent preferences that they held towards a given strategy. To address this issue, task time associated with each search strategy was systematically manipulated in the studies described in the current chapter. Indeed, relative task time was found to influence individuals' strategy selection, thereby establishing a causal link between these two variables. Individuals were also asked to provide their motivation for their strategy selection in an open-ended response format in these studies. This resulted in the identification of different subgroups that seemed to hold dispositions towards different types of search strategies. Importantly, these individual differences in strategy disposition were able to differentially predict individuals' pattern of strategy selection under different time costs. Specifically, whereas individuals who prioritized time minimization showed no preference towards one strategy or another when the two strategies took the same amount of time to complete the task, organizers preferred an organization-based strategy and searchers preferred a search-only strategy when presented with the same scenario. More importantly, the strategy selection of all three groups of individuals were influenced, to varying degrees, by relative task time. Specifically, time-minimizers were the most sensitive to changes in relative task time, preferring whichever strategy was faster regardless of how much more time they would save. Compared to time-minimizers, searchers and organizers were less sensitive to task time as a consideration when making strategy selections and were more likely to choose whichever strategy they reported having a disposition towards. In other words, organizers and searchers would only choose their non-preferred strategy if the resulting time benefit was much greater.

In addition, I also examined the extent to which an individual's tendency to select an organization-based strategy in the current task reflected a more general preference towards spatial organization. I found that individuals' self-reported level of organization in their everyday spaces were related to their self-reported strategy disposition, as well as the likelihood that they would choose an organization-based over a search-only strategy. These results are consistent with the idea that one's strategy preferences in the current task might reflect more domain general tendencies for how individuals choose to arrange their environments.

In summary, although the desire to minimize time is an important consideration behind one's choice to engage in spatial organization in everyday activities, the degree to which individuals consider time minimization when making a strategy selection also depends on their general preference towards or against spatial organization. That is, those who prefer organization will be more likely to incorporate organization into their everyday tasks, sometimes at the cost of saving time. On the other hand, individuals who generally avoid or dislike organization may only organize their spaces if the benefits of doing so are extremely apparent.

Chapter 6

In Chapter 4, I demonstrated that individual differences in strategy disposition helped to explain differences in how individuals selected their preferred strategies as a function of time. Namely, individuals who were motivated to spend less time on the task were relatively sensitive to manipulations of task time and preferred whichever strategy minimized task time. Compared to the time-minimizers, individuals who had a disposition towards a particular strategy (i.e., organizing or search-only) were less sensitive to differences in relative task time and were more likely to select their preferred strategy.

One aspect to highlight in these results is that individual differences in one's strategy disposition may also help to explain why there was a tendency at the aggregate sample level for individuals to choose the organization-based strategy over the search-only one when both strategies were expected to take the same amount of time. When the expected times taken were equal across organization-based and search-only strategies, time-minimizers did not show a preference towards either strategy; on the other hand, organizers and searchers were overwhelmingly more likely to select the organization-based and search-only strategies respectively. Across all studies presented in Chapter 4, there were always proportionally more organizers than searchers; as such, the seeming preference towards an organization-based strategy at the aggregate level likely reflected an epiphenomenon of the ratio of organizers to searchers in a given sample.

One puzzling result in Chapters 2 and 3 was that although relative task time was observed to be a consistent predictor in all cases, individuals across different samples or studies differed in their tendency to select one strategy over another at the aggregate level in situations where there was no benefit of time associated with either strategy. In particular, participants in lab-based studies were far more likely to select a search-only strategy at the aggregate level compared to participants in online samples. As mentioned in Chapter 3, one potential explanation for these differences is that having to complete the task in the lab where one is expected to actually complete the task may trigger a kind of present bias (O'Donoghue & Rabin, 1999). That is, individuals may perceive the effort or time required to organize one's task environment to loom larger when they are expected to complete this task compared to in a hypothetical scenario. However, in light of the results presented in Chapter 4, it is also possible that these sample differences may simply reflect differences in the relative ratio of organizers to searchers in a given sample. Based on this latter idea, I would expect that the more organizers there were relative to searchers in a given sample, the more likely there would be a 'bias' towards selecting an organization-based strategy at the aggregate level, and vice versa.

Study 10

Method

I combined datasets from the laboratory-based experiments involving undergraduate students from Chapter 2 (N = 152) as well as online experiments in Chapter 3 that used both undergraduate (N = 82) and Amazon Mechanical Turk samples (N = 80). Across all experiments, individuals were asked to choose between an organization-based or a search-only strategy, if they were to search for target pieces among a pile of Lego pieces. Immediately after, individuals were asked to elaborate on their reason for that decision in an open-ended manner.

Results

Analysis

All analyses were conducted using *R* (R Core Team, 2019). I report 95% profile likelihood based confidence interval for estimates reported in logistic regression models (Meeker & Escobar, 1995) as extracted using the *sjPlot* package (Lüdecke, 2018).

Sample Differences in Strategy Selection

The same procedure as described in Chapter 4 was used for independent coders to code individuals' open-ended responses into one of 4 categories: (1) time-minimizers, (2) organizers, (3) searchers, or (4) others. The inter-rater reliability was moderately high (k = .72). A third coder resolved any conflicts in the coding between the first two coders. Figure 24 shows a breakdown of the proportion of individuals with each strategy disposition based on the final coding. A chi-square test of independence showed that the proportion of individuals with each strategy disposition was different across samples, $\chi^2(4, N = 314) = 45.13$, $p < .001$. As demonstrated in Table 21, most of the in-lab sample (53.8%) reported preferring the search-only strategy, far more than those who preferred an organization-based strategy (12.5%). In contrast, the majority of undergraduates in the online sample preferred an organization-based strategy (31.7%) over a search-only strategy (19.5%), as did the Amazon Mechanical Turk participants (53.8% preferred an organization-based strategy compared to 12.5% for the search-only strategy). The ratio of organizers to searchers are also presented in Table 21.

Table 21.

Percentage (%) of individuals with each strategy disposition and ratio of organizers to searchers across different samples.

Predisposition Categories	**Undergrad In-Lab**	**Undergrad Online**	**Amazon Mechanical Turk**
Time Minimization	32.9%	48.8%	33.8%
Organization Preference	21.1%	31.7%	53.8%
Search Preference	46.1%	19.5%	12.5%
Other	0.0%	0.0%	0.0%
Ratio of Organizers to Searchers	0.46	1.63	4.30
Sample Size	80	152	82

Note: Percentages by sample type may not add precisely to 100% due to rounding.

A logistic regression also revealed that aggregate-level strategy selections for each of the 3 samples were statistically different from one another. Specifically, compared to the online undergraduate participants, who were no more likely to select one strategy over another, $b = .05$, 95% CI [-.39, .48], $z = .22$, $p = .83$, the in-lab undergraduate participants were significantly more likely to select a search-only strategy, $b = -1.01$, 95% CI [-1.58, -.45], $z = 3.54$, $p < .001$. On the other hand, individuals from the Amazon Mechanical Turk sample were statistically more likely than the online undergraduate sample to select an organization-based strategy, $b = 1.05$, 95% CI [.39, 1.73], $z = 3.09$, $p = .002$.

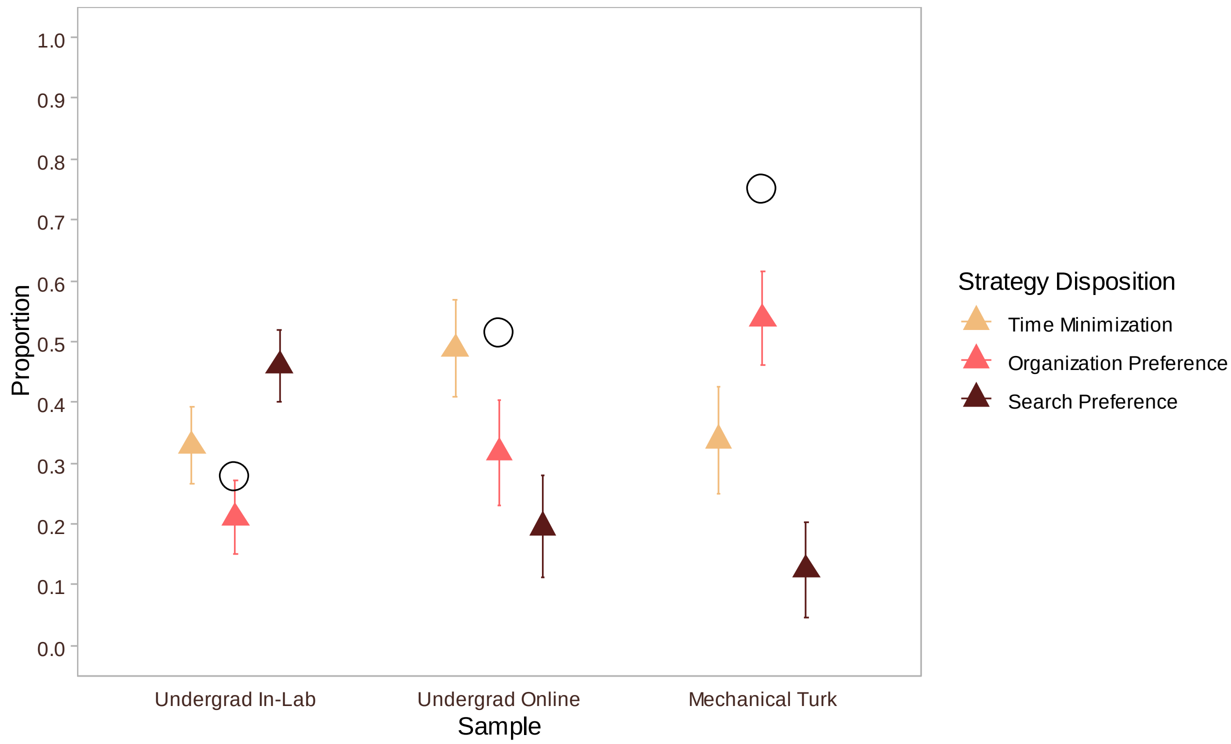


Figure 24. Proportion of individuals with a given researcher-coded strategy disposition separated by sample (solid triangles) and the mean proportion of individuals who chose an organization-based strategy over a search-only strategy in each sample (hollow circles). Error bars, when used, represent 95% confidence intervals.

Next, I examined whether the likelihood that individuals would select one strategy over another could be predicted by individuals' strategy dispositions. Based on our findings in Chapter 4, individuals with an organization preference should be far more likely to choose the organization-based strategy, and those who prefer to directly search for the target pieces would be more likely to choose the search-only strategy. Time-minimizers, on the other hand, should be equally likely to prefer each strategy.

The proportion of individuals choosing an organization-based strategy across each disposition type and sample are shown in Figure 25. Since individuals who were identified as organizers and searchers consistently chose their preferred strategy (i.e., there was no variance in the data), a full logistic regression containing these conditions would not be able to converge. Instead, a logistic regression using only the time-minimizers in each sample to predict individuals' strategy selection was conducted. Interestingly, time-minimizers in the laboratory sample were still significantly more likely to choose the search-only strategy, $b = -1.39$, 95% CI [-2.14, -.73], $z = 3.93$, $p < .001$. This was different from both the undergraduate online, $b = .98$, 95% CI [.06, 1.95], $z = 2.05$, $p = .04$, and the Amazon Mechanical Turk samples, $b = 1.92$, 95% CI [.90, 3.00, $z = 3.60$, $p < .001$, wherein time-minimizers had a relatively higher likelihood of selecting the organization-based strategy in both samples.

To follow up on this observation, separate logistic regression models were constructed for time-minimizers in each sample wherein their estimated relative task time difference was used to predict their strategy selection. To avoid quasi-separation, only individuals whose estimated relative task time did not exceed 70 minutes were included in the analysis. When the estimated relative task time between strategies was statistically controlled at 0, time-minimizers from the in-lab sample were still more likely to select a search-only strategy, $b = -1.58$, 95% CI [-3.42, -.38], $z = 2.17$, $p = .03$. This was not the case for the online undergraduate sample; time-minimizers in this sample were no more likely to select the organization-based strategy compared to the search-only strategy, $b = -.91$, 95% CI [-2.33, .17], $z = 1.50$, $p = .13$. Note that a logistic regression for time-minimizers in the Amazon Mechanical Turk sample could not be conducted due to a complete separation of data points across strategies.

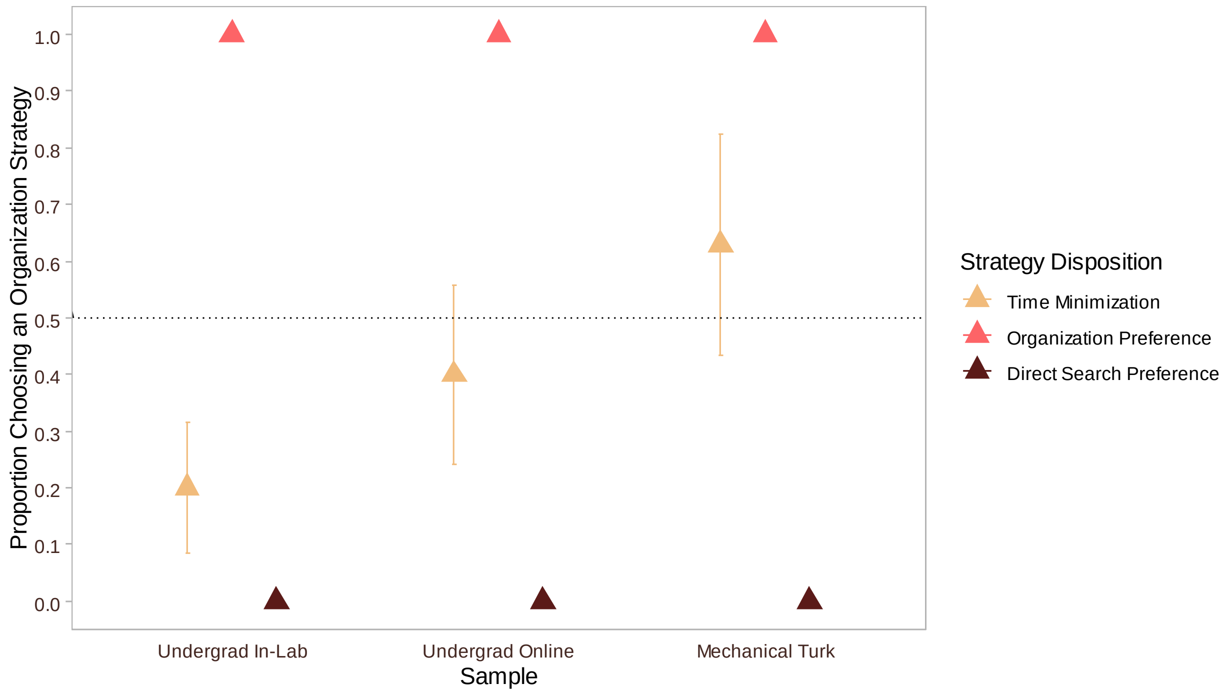


Figure 25. Proportion of individuals who chose the organization-based strategy in each sample as a function of their strategy disposition. Error bars, when available, represent 95% confidence intervals. The grey horizontal dotted line represents chance.

Discussion

In this chapter, I examined the question of whether the aggregate level tendency for individuals in a sample to select a given strategy could be related to differences in the proportion of individuals with different strategy dispositions across these samples by reanalyzing data from Studies 2 through 6. Indeed, the more organizers there were relative to searchers in a sample, the more likely individuals were to select an organization-based strategy over a search-only strategy. This suggests that the makeup of individuals with different dispositions resulted in fluctuations in which strategy was 'preferred' at the aggregate level in each sample.

Since both the online undergraduate sample and Amazon Mechanical Turk sample completed a hypothetical scenario, it is plausible that the proportion of individuals with different strategy dispositions resulted in the observed strategy preference at the sample level. While these results may also be extended to the in-lab sample, it is also possible that individuals in laboratory-based studies may simply be more inclined to identify as searchers in order to align their motivation with their strategy selection as a result of experiencing a present bias. Indeed, there was evidence that in-lab participants may truly be 'biased' towards a search-only strategy, as demonstrated in the analysis involving only the time-minimizers in each sample. Specifically, time-minimizers who were asked to make a strategy selection in a hypothetical scenario, regardless of which sample they were from, showed no clear preference for one strategy over another. In contrast, time-minimizers in the in-lab sample were more likely to select the search-only strategy, even when there was no expected benefit in task time in doing so. These results provide further support that individuals who were expected to physically complete the search task exhibited a kind of bias against organizing their work environments prior to engaging in a search task.

Concluding Remarks

In Chapter 1, I demonstrated that in a real-world setting that lacked clear, measurable performance-related considerations, where individuals decided to place themselves was largely influenced by their past spatial habits, given that that these locations were available at the time that they made their spatial decision. In later chapters, I focused on examining factors that would influence an individual's decision to engage in global spatial organization (i.e., whether individuals would choose to rearrange objects in a given space). I began this investigation in Chapter 2 by introducing a task wherein individuals selected between two strategies—one that required organizing the task space upfront and one that did not—which did not differ in objective task completion time. Consistent with previous literature (Kirsh, 1995, 1996), I found that performance-based considerations do seem to underlie individuals' strategy selection to an extent, in that individuals tended to choose whichever strategy was perceived to result in net time savings. However, when asked to make this strategy selection prior to engaging in the search task, there was a 'bias' for individuals at the aggregate level to select a search-only strategy, even when the perceived time benefit across strategies was statistically controlled at 0. Interestingly, aggregate-level strategy selection reversed post-task, such that individuals were more likely to select an organization-based strategy overall. This post-task selection 'bias' could be partially explained by individuals' past selection decisions, as well as by the strategy that they were assigned to use to complete the real-world search task. I attempted to replicate the results found in Chapter 2 by using two different online samples in Chapter 3. Further, other performance-based considerations—perceived task effort and enjoyability—were introduced along with perceived task time. In addition to perceived task time, perceived task enjoyability also emerged as a predictor of individuals' strategy selection; perceived task effort, on the other hand, was not a consistent predictor. Further, there also seemed to be sample differences in which strategy was preferred at the aggregate level: participants selected from a Mechnical Turk sample were far more likely to select an organization-based strategy, whereas undergraduates did not seem to prefer either strategy. In Chapters 4 and 5, I found that there was significant variation in the degree to which individuals considered task time when making strategy selection. I identified 3 groups of individuals with varying strategy dispositions. Time-minimizers seem only sensitive to relative task time when compared across the different strategies, choosing whichever strategy that would lead to a net time saving. Organizers, on the other hand, would be more likely to choose the organization-based strategy, even when doing so led to spending more time on the task. Searchers behaved similarly to organizers, except that they would more consistently choose the search-only strategy out of the two. Both organizers and searchers also had the capacity to consider task time when it was made more salient across different scenarios, but their strategy selection was more strongly rooted in their strategy disposition. Interestingly, the ratio of organizers to searchers in a given sample seemed to be associated with the degree to which individuals preferred a given strategy at the aggregate level, such that a sample with more organizers would also tend to show a stronger 'bias' towards individuals selecting the organization-based strategy.

Altogether, the studies outlined in the current dissertation provide evidence that human spatial organization can be influenced by multiple factors that sometimes compete with one another for expression. These results may help to explain discrepancies observed in previous work wherein individuals' spatial decisions do not align with a unitary performance-based account (Berry et al., 2019; Solman & Kingstone, 2017a; Zhu & Risko, 2016). The multi-factor framework outlined in the current dissertation can be applied to both the general decision for individuals to engage in spatial organization on a more *global* scale as well as *local* spatial decision about *where* to place specific items or persons. Whether at the global or local scale, performance considerations have been shown to be a key driver of spatial decision. In Chapters 2 through 5, individuals demonstrated considerable sensitivity to time, and selected strategies that often led to the minimization of either perceived or objective task time. However, the degree to which individuals considered task time in their strategy selection was modulated by individual differences in strategy disposition. Those who hold a distinct preference towards a given strategy may assign it special value or utility that would otherwise be inaccessible to an objective observer. These *perceived* utilities effectively shift one's criterion for selecting one strategy over another; for instance, those with a disposition towards spatial organization would readily choose an organization-based strategy, even though doing so may hinder their performance. Importantly, one's search strategy disposition seems to reflect more domain general preferences for engaging in spatial organization. These results echo previous research showing that individual differences in personality traits can predict systematic differences in the way individuals arrange their personal space (Gosling, 2008; Gosling et al., 2002).

Whereas individual differences broadly modulate the perceived utility of performance-related factors associated with spatial organization, variables that influence the specific placement of objects (or oneself) are more likely to compete with one another for expression. As demonstrated in a number of studies, individuals will spontaneously rearrange objects in their environment in a way that helps to reduce physical effort (Solman & Kingstone, 2017a; Zhu & Risko, 2016). Yet, these performance-related considerations—rearranging one's space to minimize physical effort—often compete with a seemingly natural desire for individuals to maintain the placements of these objects in space—a tendency driven by one's pre-existing spatial habits. As demonstrated in Chapter 1, individuals tended to base their spatial decisions, at any given point in time, on past spatial decisions when they were embedded within an environment that lacked clearly measurable performance benefits (i.e., a classroom setting). That is, the longer they spent within that environment, the more fixed their placements within that space became.

The works presented throughout this dissertation offer a glimpse into the complexity and multifaceted nature of human spatial organization waiting to be discovered. Given the relative novelty of this area of research, much of the examination thus far has been centered around demonstrating—or refuting—the notion that spatial organization is rooted in performance-related considerations. However, spatial organization may have other implications that have yet to be explored in depth. For instance, one area that has received limited attention within the study of human spatial organization is understanding the *functional* costs or benefits—whether cognitive or physical—offered by organizing one's environment. I hope that the present investigation will provide the building blocks to establish a more rigorous, nuanced, and systematic understanding of how humans engage in spatial organization.

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